AN INVESTIGATION OF AIMING POINT STRATEGIES FOR
FIELD ARTILLERY AGAINST AREA TARGETS

A THESIS

Presented to

The Faculty of the Division of Graduate Studies

By

Lawrence Carl Petersen

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Operations Research

Georgia Institute of Technology

June, 1978

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ABSTRACT

SUMMARY

In this study an optimal aiming point strategy is sought for the attack of rectangular area targets with field artillery weapons firing conventional high explosive projectiles, assuming the capability of applying individual firing data to each weapon. A deterministic computer simulation model is used to test a number of aiming point patterns for two, four and six gun batteries, firing single volleys at each of ninety targets defined over a range of target conditions. The results for each pattern are compared in terms of expected fractional damage to the target. Included in the tested patterns are the standard Lazy W Aiming Point Pattern and a rectangular pattern which has been proposed for the Battery Computer System (BCS).

ABSTRACT

An aiming point strategy is proposed for which the spacing between aiming points in both range and deflection directions are allowed to vary with changes in the targets size and shape and with changes in delivery error parameters. This "Variable Aiming Point Strategy" is defined by a set of simple mathematical models. The Variable Aiming Point Strategy is found to achieve expected fractional target damage improvements of more than three times that of the Lazy W Pattern and up to approximately twenty percent above that of the aiming

point strategy which has been proposed for the Battery Computer System.

CHAPTER I

INTRODUCTION

Description of the Problem

When attacking an area target with field artillery weapons, the object is to inflict the maximum number of casualties or amount of damage to material (maximum target coverage) possible, given the number of rounds fired. If the dimensions and location of the target were precisely known, if the target elements were uniformly distributed in the target area, and if the projectiles could be fired with perfect accuracy, then the desired maximum coverage could probably be achieved by firing at points which were in some way uniformly distributed throughout the target. Such a set of uniformly distributed points could be referred to as an optimal set of impact points. Unfortunately, due to delivery errors, artillery projectiles do not impact precisely on the point at which they are aimed. Using expected target coverage as a measure of effectiveness, the optimal set of aiming points for a given situation (i.e. target and set of error distributions) would be those aiming points which would result in the maximum coverage of the target. For a given situation these optimal aiming points are not necessarily the same as the optimal impact points defined above.

In fact, they are often strikingly different.

Because of the requirements for timely fire support in combat, any aiming point strategy which required that separate firing data be computed for each howitzer has in the past been infeasible. Except for very special cases, a parallel sheaf procedure, with a "Lazy W" aiming point pattern, augmented in recent years with "terrain gun position corrections," has been used to attack area targets. These methods are described in Chapter III. Current computer technology, however, and in particular the development of the Battery Computer System (BCS), will soon make individual targeting of each weapon a feasible reality. A fuller undertanding of the relationship between aiming points, error factors, and target coverage will enable the Army to take fuller advantage of systems such as the BCS.

The military necessity for using our advanced technology to optimize our weapons systems is clearly illusstrated by a brief comparison of the opposing forces in central Europe (NATO vs. WARSAW PACT). In an article on force multipliers, published last June, it was estimated that we are "outnumbered about 1.4 to one in manpower, at least three to one in tanks, three to one in artillery, and two to one in tactical aircraft" [31]. Since the United States has no monopoly on technology, it will be increasingly difficult to maintain a technology - intensive force structure capable of overcoming this out-manned,

out-gunned situation in Europe. So, while economic considerations make the development of an optimal aiming point strategy desirable, the potential military threat posed by the Soviet Union makes it imperative.

Objective of The Research

The objective of this research is to develop and demonstrate a procedure for determining an aiming point strategy which will produce optimal target effects in terms of expected fractional target coverage.

Several aiming point strategies which could be used to attack area targets of various size and shape, across a range of error parameters, by various size artillery batteries were investigated. A variable aiming point strategy was then designed to cover the range of circumstances investigated. This strategy is in the form of a mathematical model which can be readily programmed into a computer system such as the BCS, and which will produce a set of optimal or near optimal aiming points for the attack of a target situation defined by a set of input parameters. Using computer simulation, a comparison of strategies has shown that the variable aiming point strategy will achieve expected fractional target coverage which ranges to more than three times that of the Lazy W parallel sheaf and to nearly 20% above that of the aiming point strategy which has been proposed for the Battery Computer System. These results apply only within the limits of target situations defined

by the scope of the study.

Scope for the Research

The research was conducted for a hypothetical medium howitzer, with characteristics similar to the U. S. Army's 155 mm, M109A1, Self-propelled Howitzer. Two, four, and six gun batteries were simulated, firing missions of one volley of high explosive projectiles. Since lethal area data for specific types of targets are classified, a hypothetical soft target was simulated with a lethal area of 600 square meters. Target location error was assumed to be zero.

All targets used in the study are rectangular with one dimension running parallel to the direction of fire. Throughout this report the length of the target refers to the range dimension of the target or the dimension parallel to the direction of fire. The width of the target refers to the deflection dimension or the dimension perpendicular to the direction of fire. Targets range in size from 5,000 to 20,000 square meters for the six gun battery and from 2,500 to 10,000 square meters for the four and two gun batteries. The shape of the targets are expressed as a ratio of target length to target width and range from 0.20 to 5.00.

Delivery error distributions, for both precision error and mean point of impact error, are considered to be functions of range; and ranges of 4,000 meters to 12,000 meters are considered. Since delivery error distributions vary with angle of fall and thus with the powder charge

fired, preference was given to charges with the least probable error in range, from the charge selection table on page LXI of the firing tables for the M109 howitzer. Further discussion of the delivery error distributions used can be found in Chapter V.

Eleven aiming point patterns were defined for investigation of the six gun battery, in addition to "current procedure" stategies which are used for comparison purposes. Five patterns for the four gun and four patterns for the two gun battery were also investigated. All aiming point patterns are described in Chapter V.

In addition to studying the variables within the limits discussed above, some points outside of these limits were sampled and the results are discussed in the section on sensitivity in Chapter VI.

CHAPTER II

LITERATURE REVIEW

The Coverage Problem

A review of the literature revealed that a great deal of research and writing has been done on methods of computing expected fractional damage to be achieved by artillery shelling, missiles and bombs. Procedures have been developed for point, linear, and area targets of rectangular, circular, and elliptical configurations. Several reviews of coverage problem literature are available, such as Eckler's "A Survey of Coverage Problems Associated with Point and Area Targets" [20], and "A Review of the Literature on a Class of Coverage Problems" by Guenther and Terragno [23]. This thesis benefited from the extensive literature review of effectiveness studies and computer models conducted by Captain Robert M. Alexander for his Master's Thesis at Georgia Institute of Technology, June, 1977, as well as from his personal notes which were graciously provided prior to his departure [1].

Of the less numerous papers dealing specifically with the question of optimal aiming point strategy, the following are of particular interest.

An article was written in 1955 entitled, "Optimal Ammunition Properties for Salvos" by Walsh [34]. A salvo

is an attack with all weapons aimed at the same aiming point and fired simultaneously. Walsh presents a method for evaluating maximum salvo kill probability and the corresponding optimum round-hit-location probability distribution.

In 1968 Ballistics Research Laboratories published the paper, "Expected Target Damage for a Salvo of Rounds With Elliptical Normal Delivery and Damage Functions," by Grubbs [22]. Grubbs obtained a series expansion for the expected fraction of damage to a circular target when it is assumed that a salvo of n rounds is delivered onto the target area with a non-circular normal distribution and the damage function for each round can be represented by a non-circular exponential square fall-off law.

In "Expected Target Damage for Pattern Firing," [6] Bressel extended the method introduced by Grubbs to a pattern distribution. He evaluates analytically the damage function for a rectangular target from a firing pattern of n rounds. The delivery errors, mean point of impact and precision error, are both assumed to be non-circular normal and the damage function is defined to be a non-circular exponential square fall-off. Bressel's results were computationally complex and not suitable for manual use, but his work was useful in the later development of computer models capable of evaluating expected coverage for pattern fire.

Models

Several computer simulation models have been developed for the purpose of studying the coverage problem. In fact, a large portion of the related literature involves the development and presentation of models. They range from simple effectiveness models that have been developed for programmable pocket calculators [12] to detailed models such as "FAST-VAL: Target Coverage Model," developed by the Rand Corporation with such lengthy computer run time requirements as to render its use undesirable for studies such as this one [32].

In 1963, the Operations Evaluation Group, Center for Naval Analysis, presented the Weapons Pattern Effectiveness Model by Westlund and Depoy [35]. This model employs a Monte Carlo technique to obtain the probabilities of at least any given number of operable hits on a rectangular target. The most desirable characteristic of this model is its capability of analyzing rectangular targets with neither axis parallel to the direction of fire. Unfortunately, the output (probability of a given number of hits) cannot be translated into fracitonal damage.

A study prepared by Kasper [26] in 1967 produced a mathematical model and computer program that could be used to determine fraction of casualties caused by firing rounds at different aiming points in an area target. This model employs a "hit probability distribution" and does not distinguish between precision error and mean point of impact error.

Breaux presented a method for computing expected fractional kill of a circular target in 1967, [4] followed in 1968 by a method for handling the more general case of an elliptical target, involving both round to round (precision) and occasion to occasion (mean point of impact) errors by Breaux and Mohler [5]. This method employs Jacobi polynomials to overcome the computational difficulties encountered when the number of rounds fired is large. Both procedures simulate a salvo of area damaging rounds all aimed at the same aiming point. A model by Hess, presented in 1968, is also limited to salvo fire [24].

Oman developed a method for evaluating coverage functions for the Rand Corporation in 1970 [30]. This model employs FORMAC, an IBM symbolic mathematical compiler, and the paper was written to demonstrate how FORMAC could be used to apply a cumbersome mathematical approach to a real world problem. In the model Oman expressed the probability of destruction in terms of a set of multiple integrations whose initial integrands contain distributions relating to the weapon and the target.

Two models were found in the literature which were considered suitable for this research. These are the BDM Services Company's "The KABOOM Firepower Model," by Porter and Hyams, [3] and Rand Corporation's "A Simplified Weapons Evaluation Model," by Snow and Ryan [33]. The BDM Model uses a Monte Carlo process to generate random draws and

varies the distribution errors used to describe the precision and mean point of impact error deviation. Targets and damage functions are both assumed to be circular. The output of the model is the probability of a kill based on rounds-on-target and the mean and variance of the probability of a kill for a given strategy.

The Rand Model was written for research on the use of airpower in support of ground operations. It was modified for a field artillery application by John Bloomquist of the U. S. Army Materiel Systems Analysis Activity (AMSAA). The artillery version is called "SNOW'S QUICKIE." This is a deterministic model for attaching rectangular targets and the output is expected fractional coverage.

SNOW'S QUICKIE was recommended by AMSAA, the sponsor for this research,and is currently being used for weapons effectiveness studies by the Directorate of Combat Development, United Stated Army Field Artillery School at Fort Sill, Oklahoma. This model was selected for use in this study for several reasons. While the BDM model is limited to circular targets, SNOW' QUICKIE is designed for the evaluation of rectangular targets, which allows for the description of a wider variety of targer shapes. It employs a gaussian damage function which is elliptic in that probability contours are all ellipses with the same eccentricity. This is more consistent with other artillery research than is the circular damage function used in the BDM model. The deter-

ministic simulation of SNOW'S QUICKIE is more efficient for handling the large number of combinations of target size, shape, and delivery error than a Monte Carlo simulation technique would be. And finally, the results of SNOW QUICKIE are accepted by the Field Artillery community as evidenced by its current use at Fort Sill. This model is discussed in more detail in Chapter IV.

CHAPTER III

ARTILLERY BACKGROUND

Mission

"The mission of the field artillery is to provide continuous and timely fire support to the force commander by destroying or neutralizing, in priority, those targets that jeopardize the accomplishment of his mission" [7]. That sentence is one of the keystones to the education of every American Field Artillerymen. One of the most critical words in that sentence is "timely." If artillery support is not delivered very rapidly when it's called for, it will often be useless. When firing data has to be computed by hand it can be a time consuming business even for the best trained fire direction center crews. So, in order to minimize the required computation time, the "parallel sheaf" procedure, which requires that only one set of data be computed, has been used for the attack of area targets.

Parallel Sheaf

A target is covered by fire by controlling the pattern of burst (sheaf) on the target. When a battery of howitzers fires a parallel sheaf (all weapons firing the same elevation and deflection data) the rounds impact in

the target area in generally the same pattern as the piece displacement in the battery area. The only data required for this procedure is that necessary for the center weapon to hit the center of the target. Coverage of the target by other weapons (the coverage pattern) is determined by the way the howitzers are arranged in the battery area (the piece displacement.) Effective burst widths have been established for each caliber of weapons (See Figure 1) and an "open sheaf" is defined as a pattern of bursts in which the lateral distance between the centers of two adjacent bursts equals one effective burst width. By emplacing the battery with one effective burst width between adjacent howitzers and firing a parallel sheaf, the theoretical effect in the target area would be an open sheaf. In order to add some depth to the impact pattern, a common formation called the "Lazy W" is frequently used. Figure 2 illustrates a battery in Lazy W formation firing a parallel sheaf to achieve an open sheaf in the target area. Note that the size of an "effective burst width" is fixed for a given caliber and does not change with the nature of the target. Note also, that delivery errors are not included in this model.

This method has provided the basis for artillery firing for many years. It should be pointed out that some flexibility is provided by the "converged sheaf" (Figure 3) generally used for attacking point targets and by the

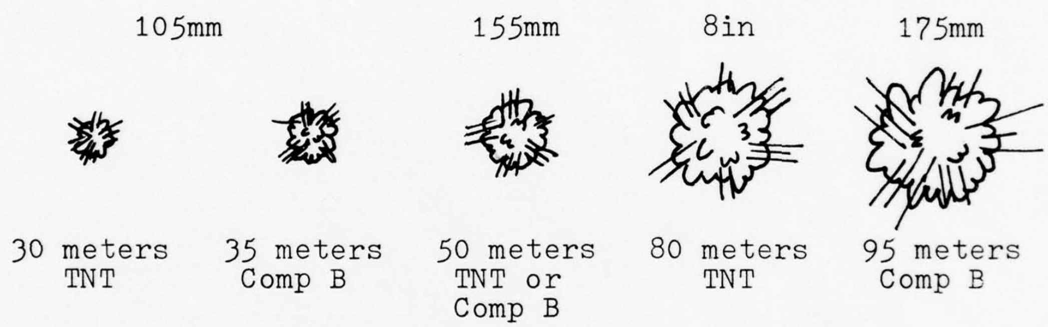


Figure 1. Effective Burst Widths

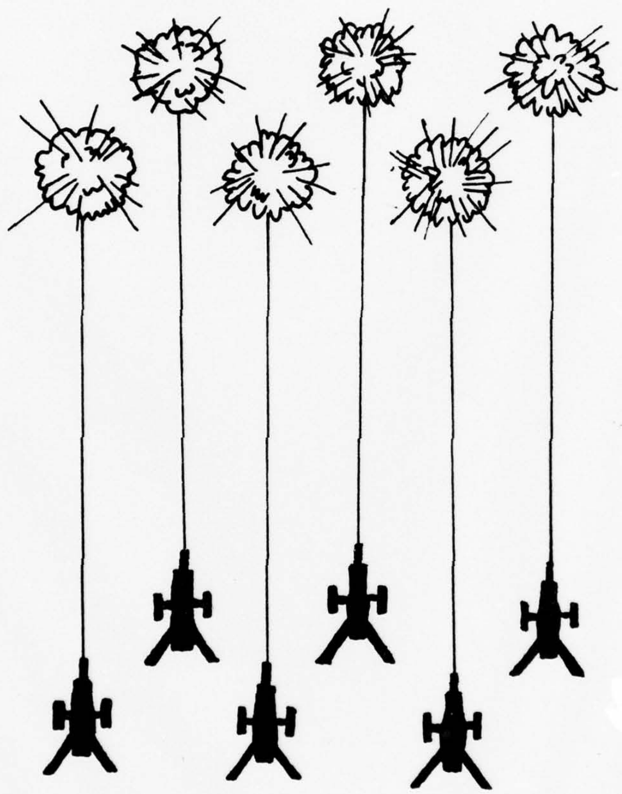


Figure 2. Lazy W Formation, Parallel Sheaf, Open Sheaf

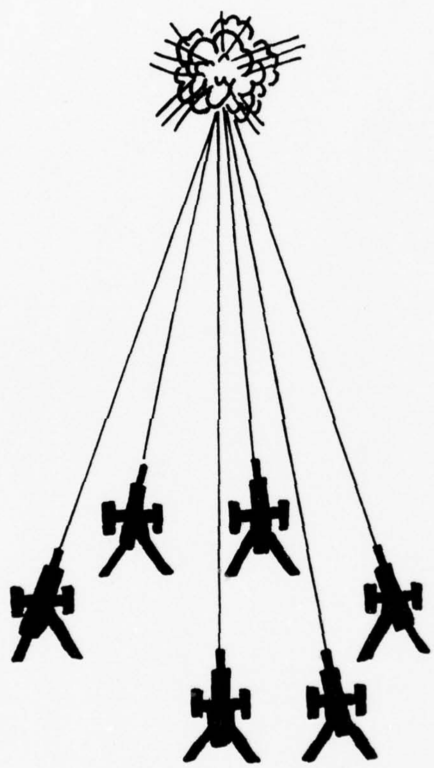


Figure 3. Converged Sheaf

"special sheaf" (Figure 4) which involves individual data for each weapon, (called special corrections) for the very special situation in which it is feasible to tailor the impact pattern to the specific shape of the target [8].

Terrain Gun Position Corrections

As enemy target acquisition capabilities improve, a battery of howitzers emplaced in Lazy W formation on an open patch of ground becomes a very lucrative target. So to enhance survivability it will be necessary to take maximum advantage of the natural cover and concealment offered by the terrain when positioning artillery batteries. For this situation a procedure has been developed which involves the use of "terrain gun position corrections" (TGPC). TGPC are precomputed individual piece corrections applied to the gunner's aid on the panoramic telescope and the correction counter on the range quadrant of each howitzer. They are designed to provide a standard sheaf on-line at the range used to compute the corrections. The width of a standard sheaf is smaller than the width of an open sheaf. This is meant to compensate for the expansion of the impact pattern as the battery fires at greater ranges than the center range of the TGPC sector. A comparison of the widths of open and standard sheafs is given in Table 1.

TGPC are most accurate at the range and direction for which they are computed. They are considered valid

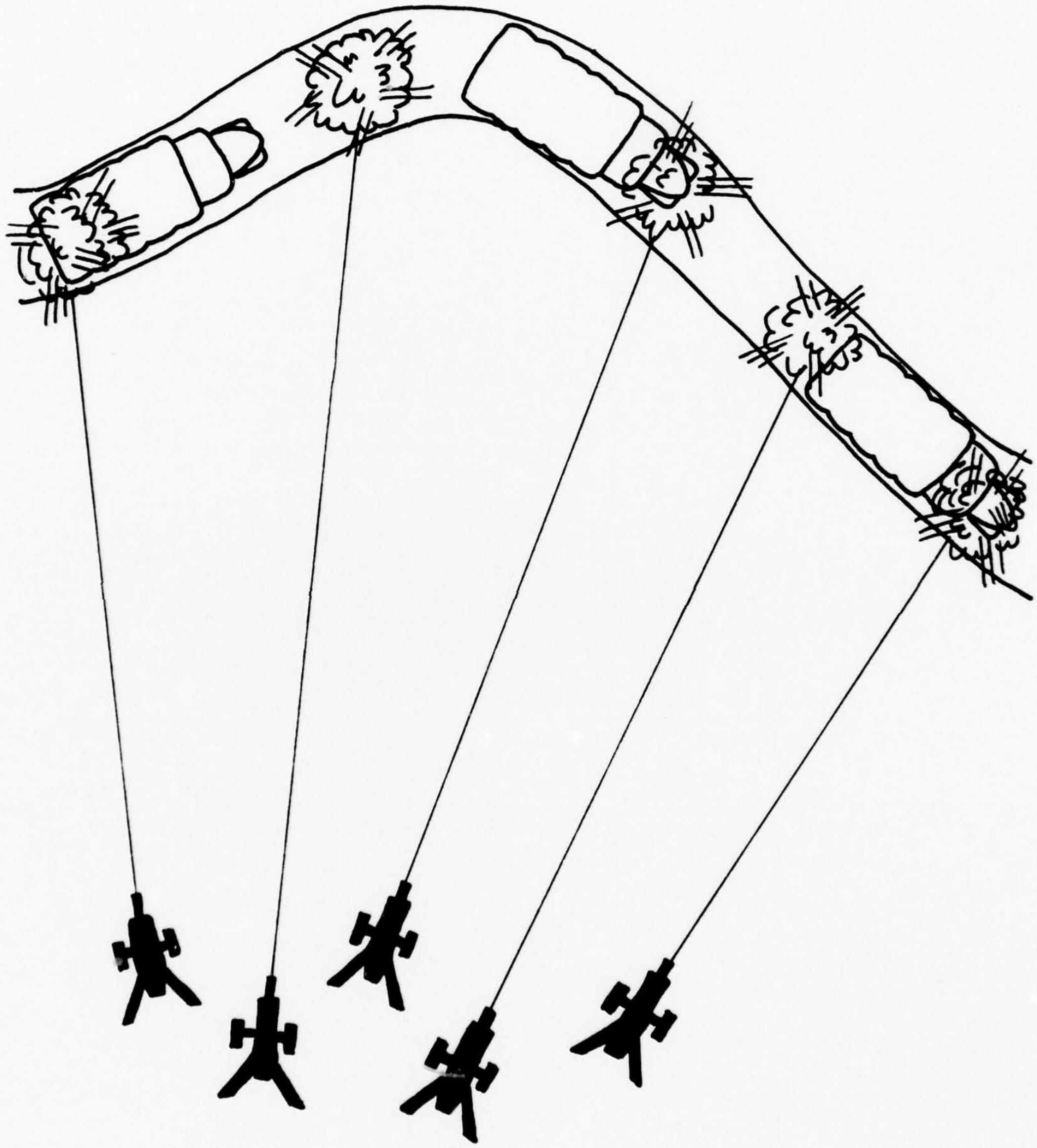


Figure 4. Special Sheaf

Table 1. Sheaf Widths

Caliber of Weapon	Guns Per Battery	Open Sheaf (meters)	Standard Sheaf (meters)
105 mm	6	150	100
155 mm	6	250	200
8 in	4	240	180
175 mm	4	285	180

within specified "transfer limits" (up to 2,000 meters over and short of the center range and up to 400 mils right and left of the center azimuth of the sector.) Since a battery's area of responsibility may cover an area larger than that within TGPC transfer limits, current doctrine calls for computation of three TGPC sectors. Ranges to the center of each sector may be different and overlapping sectors for different charges may be necessary. Figure 5 illustrates TGPC transfer limits for three sectors. TGPC is said to provide "an acceptable effect on the target" (within transfer limits), provided the battery position is located within a rectangle no more than 400 meters wide and 200 meters deep. When the battery position size limitation or the transfer limits are violated, current doctrine is to use "special corrections" [9].

Special Corrections

Special corrections are individual piece corrections designed to place the burst from each weapon on a precise point on the target. Because of the time required to compute, communicate, and apply individual piece corrections for each weapon, this procedure is reserved for rare cases, such as when firing in close proximity to friendly troops, when firing at a precisely located point or linear target, or when faster procedures such as a parallel sheaf or TGPC will not provide effective results [16].

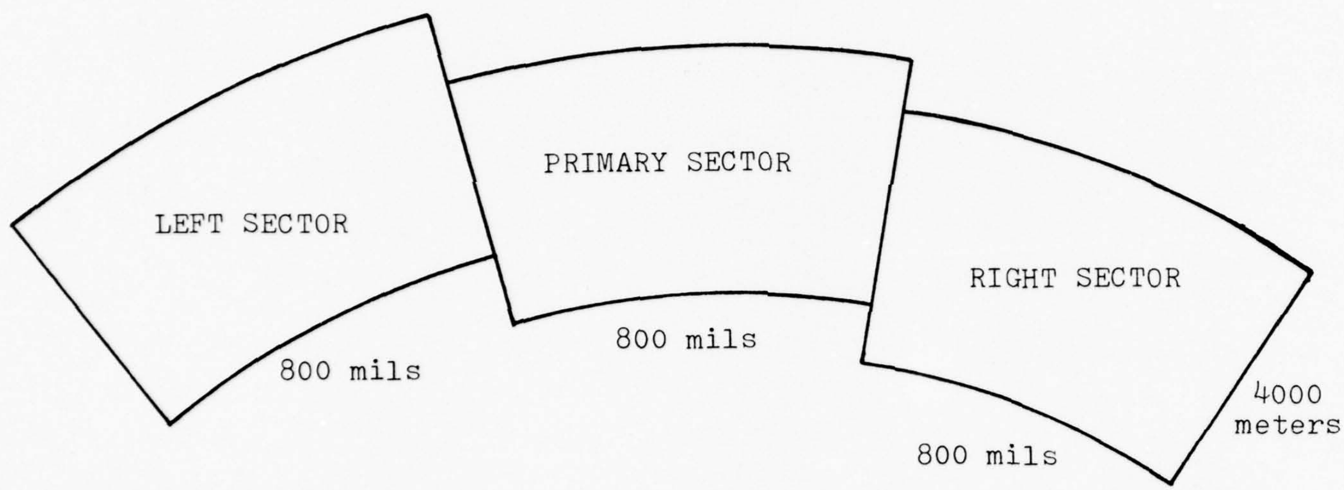


Figure 5. TGPC Transfer Limits

FADAC and TACFIRE

In the late 1960's field artillery units began to use the M18 gun direction computer FADAC. FADAC is a solid state, nonvolatile, digital computer especially designed to solve the gunnery problem. Programs for different weapon systems are fed into FADAC on coded paper tape. In addition to solving traverse, intersection, and observer orientation survey problems, FADAC will solve for the optimal charge, deflection, time of flight or fuse setting, and quadrant elevation [14]. Although FADAC improves speed and accuracy of computations, the resulting firing data is essentially the same as that produced by manual methods. With FADAC the use of individual firing data for each howitzer still involved severe delays in the fire support and were therefore still reserved for special circumstances only.

The field artillery will move fully into the computer age with the introduction of the Tactical Fire Direction Support System (TACFIRE) which is currently being field tested by the TRADOC Combined Arms Test Activity at Fort Hood, Texas. TACFIRE is a computerized fire support command and control system with a wide range of capabilities, among which are tactical and technical fire control. The term tactical fire control includes evaluating targets, selecting units to fire, munitions to be used, and volume of fire. Technical fire control means the computation of firing data for a specific fire mission. After computing base piece firing data, the TACFIRE computer will transmit the data

data to the appropriate Battery Display Units (BDU). The BDU, located in the battery fire direction center, will be a one-way device capable of receiving, decrypting, and printing messages from the computer. The firing data will then be sent to the guns using existing procedures, and parallel sheaf or TGPC type missions will be fired [18].

Battery Computer System (BCS)

With an anticipated fielding date in the 1980 to 1981 time frame, the Battery Computer System (BCS) will finally provide a realistic, feasible method of firing individual data for each weapon. The BCS, under development for the U. S. Army by the Norden Division of United Technologies Corporation, will replace FADAC and the TACFIRE Battery Display Unit in the battery fire direction center. The BCS will interface with TACFIRE. Normally the TACFIRE computer will do the fire planning and transmit the base piece firing data to the BCS. The BCS will receive this data, compute individual firing data for each weapon, and transmit the appropriate data to each of up to twelve gun display units (GDU) located up to 1,000 meters from the BCS. Each GDU contains a section chief's assembly (a small handheld unit similar to a pocket calculator, that stores complete mission data for the section chief's supervision and control requirements) and two gun assemblies, which will be mounted on the howitzer for easy viewing by the gunner and assistant gunner, and display the quadrant elevation and deflection [17].

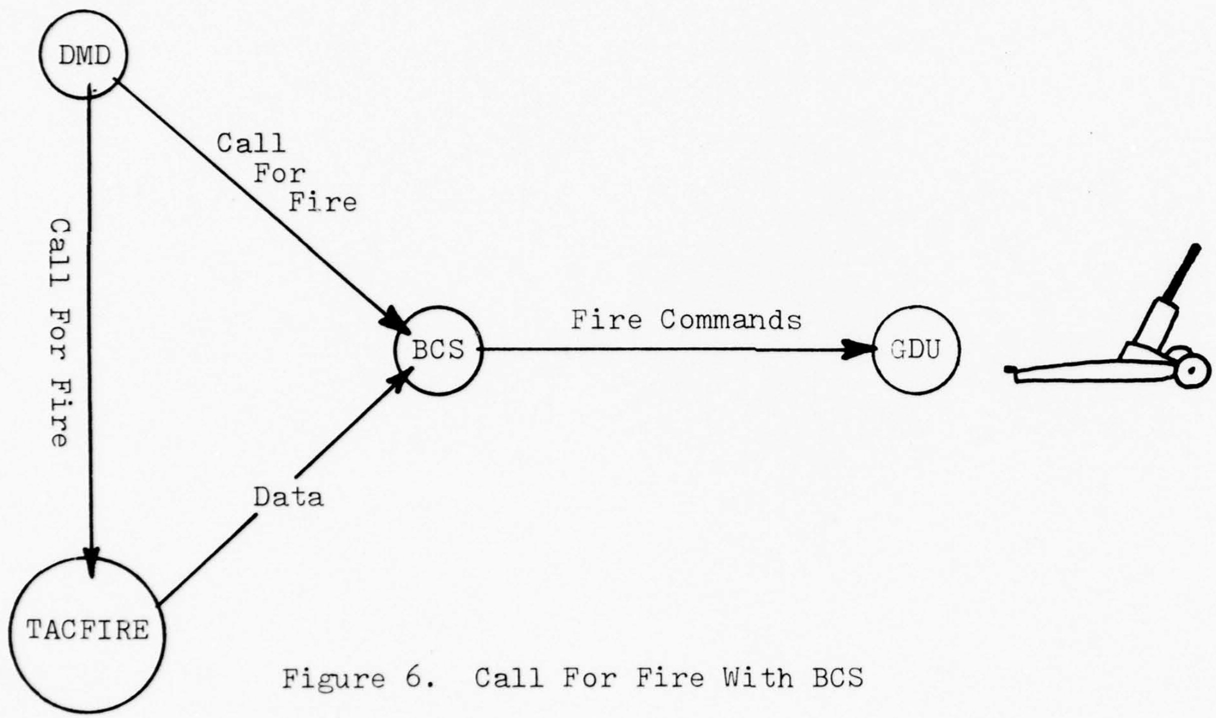


Figure 6. Call For Fire With BCS

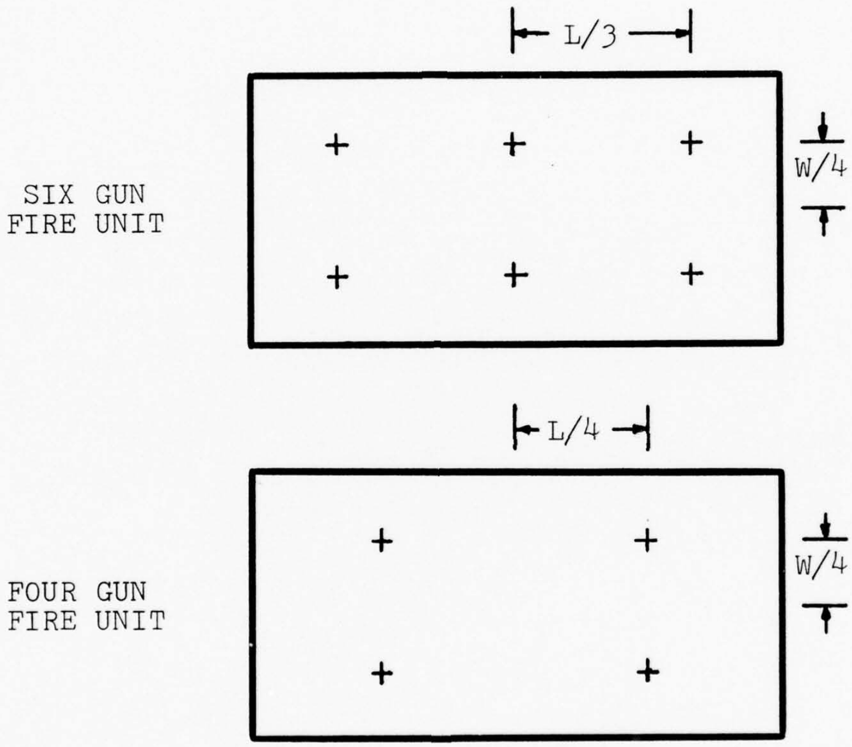


Figure 7. BCS Aiming Point Strategy

BCS will also have the capability to compute firing data from a call for fire input directly into the BCS, when the battery is operating independently or when it cannot communicate with the battalion TACFIRE. For this purpose the BCS will interface with the forward observer's Digital Message Device (DMD) and the Ground Vehicular Laser Locator Designator (GVLLD). These devices will provide digital transmission of the call for fire and accurate target location from the forward observer to the BCS [29]. The call for fire options are illustrated in Figure 6.

The proposed aiming point strategy for four and six gun batteries against rectangular targets is illustrated in Figure 7. The strategy consists of dividing the target into a number of subtargets equal to the number of weapons being fired and using the center of each subtarget as an aiming point. The strategy will be referred to as the BCS aiming point strategy throughout this report [17].

Damage Criterion

A common misconception about artillery is that all or nearly all of the elements of a target must be destroyed for the attack to be considered a success. To achieve a high probability of destroying every target element for even a relatively small target with conventional high explosive projectiles would require a prohibitively large number of rounds. Fortunately, the destruction of all target elements is seldom required in combat. FM101-31-1

defines two general levels of damage which can be used as realistic objectives for attacking targets with artillery. These two levels are combat destruction and combat neutralization [10].

A "destroyed" unit is one which has been rendered completely combat ineffective. The loss of command facilities, materiel, and many key personnel will require withdrawal from action, complete reorganization, replacement of many personnel, resupply, and extensive retraining. Coverage of thirty to fifty percent of most combat units is generally sufficient to destroy the unit [10].

A "neutralized" unit is a unit which has been rendered incapable of interfering or participating effectively in a particular tactical operation. The loss of some key personnel, command facilities, and materiel should be sufficiently extensive to require some local reorganization, improvisation of command and control procedures, minor repairs, and limited resupply to make the unit combat effective. "Coverage of ten or more percent of a unit generally will be sufficient criterion to consider the unit neutralized, providing other factors are not overpowering" [10]. For the combat scenario envisioned for this study (See Cahpter V) combat neutralization (ten percent expected fractional target coverage) would be a realistic objective for an artillery attack.

CHAPTER IV

THE COMPUTER MODEL

Snow's Quickie

The computer simulation model used in this study is SNOW's QUICKIE, a version of Snow's Simplified Weapons Evaluation Model modified for an artillery application. Originally developed by Snow and Ryan for a United States Air Force Project at the Rand Corporation, the original model was designed to evaluate both fragmentation sensitive and impact sensitive targets. The Quickie version retains the fragmentation sensitive application. The model replaces the empirical damage function used in previous models with a less time-consuming analytic expression. The result is a model which can compute non-linear weapons evaluations without materially reducing the accuracy of the answers, in as little as one hundredth of the computer time previously required.

The model requires certain restrictions. The target must be a rectangular area target (uniform distribution of target elements in the area) with a gaussian aiming error distribution. It is necessary that the damage function be an analytic function, rather than an empirical function and be integrable in a closed form with respect to the ballistic

error distribution. Furthermore, the ballistic error distribution must be one of three types: gaussian, uniform, or stick type. (A stick distribution describes the ballistic dispersion of a cluster of weapons such as bombs from an aircraft.) Under these restrictions, the coverage computations are reduced to a single stage, involving only one double integration. The output of the program is a particular value of K (expected fractional coverage) depending on the parameters considered, such as aiming errors, ballistic errors, spacing between weapons, and weapons effectiveness indices.

The damage function is of the form:

$$D(x,y) = D_o \exp\left(-D_o\left[\frac{x^2}{R^2(1)} + \frac{y^2}{R^2(2)}\right]\right)$$

where $D(x,y)$ is the probability that a target element at (x,y) will be damaged to a specified degree. $R(1)$, $R(2)$ and D_o are parameters obtained from empirical data. D_o for the HE Artillery Projectile has the value 0.2. The lethal area determined empirically for each weapon/target/range/charge configuration is R^2. The damage function used by the artillery is elliptical with eccentricity ρ (2.0 for the HE projectile). $R(1)$ and $R(2)$ may be determined from the equations:

$$R^2 = R(1)\,R(2)$$

and

$$\rho = \frac{R(1)}{R(2)}$$

SNOW'S QUICKIE combines target location error and MPI error into aiming error t(1) and t(2) in range and deflection direction using the equations:

$$t(1) = \sqrt{TLE^2 + MPIR^2}$$

$$t(2) = \sqrt{TLE^2 + MPID^2}$$

The aiming error is assumed to have a noncorrelated bivariate normal distribution:

$$\mathrm{Prob}(x \leq X, y \leq y) = \int_{-\infty}^{X}\int_{-\infty}^{y} \exp\left(-\tfrac{1}{2}\left[\frac{x^2}{t^2(1)} + \frac{y^2}{t^2(2)}\right]\right) \frac{dx\,dy}{2\pi t(1)t(2)}$$

The ballistic errors are assumed to be independent in range and deflection and also to have a bivariate normal distribution.

The model subdivides the target into small intervals, estimates the damage to each subtarget from each weapon

according to the error distributions and damage function and then sums the damage and divides by the area of the target to arrive at an expected fractional damage [34].

Modifications to the Model

For the purpose of this study, subroutines were added to the model to search each of the control parameters for each variable pattern considered, using a cyclic coordinate procedure. At each iteration of the search in each parameter "direction" an additional subroutine (GOLD) was used to calculate the next value for the parameter according to the Golden Section Rule. A final subroutine (EVAL) was designed to route the set of aiming points for each step of the search through the main deck of the model to produce and evaluation in the form of expected fractional damage to the target. Termination criterion for each step in the search consisted of an interval of uncertainty of less than one meter.

The entire model SNOW'S QUICKIE, with additional subroutines is provided an Appendix C.

CHAPTER V

PROCEDURE

General

In this study, a number of aiming point patterns are tested and compared over a range of target conditions in order to determine the most effective aiming point strategy for the attack of area targets with two, four, and six gun batteries of conventional field artillery. Although an experimental approach is used, the measure of effectiveness (expected fractional damage to the target) is determined directly with a deterministic computer simulation model, SNOW'S QUICKIE, rather than by the actual firing of howitzers.

The primary factors considered were targer size and shape, range to target (which represents the various delivery error distributions) and the aiming point patterns. The term "target mission" is used to refer to a specific set of target conditions including the range from which the target is attacked as well as the target's size and shape. Ninety target missions were defined for each battery size as combinations of three ranges, three target sizes, and ten target shapes. Each aiming point pattern was tested on all ninety target missions and the results were compared to determine which pattern is most effective for each battery size. Since the

dominant aiming point pattern is variable (the spacing between aiming points varies as the mission parameters vary) equations were found which approximate the relationships between target mission parameters and the spacing between aiming points in the pattern. These equations form the basis for the variable aiming point strategy. After a brief discussion of the tactical scenario upon which the study is based, a detailed account of the treatment of all target variables is given, followed by a description of the aiming point patterns tested.

Tactical Scenario

Sometime in the early 1980's Soviet ground forces are attacking across Central Europe on a broad front. NATO units are engaged in a delaying action as strategic forces are being mobilized in the U. S. Neither side has initiated the use of tactical nuclear weapons, but in anticipation of our doing so, the Soviets are maintaining a dispersed attack formation over one hundred kilometers in depth and are moving forward in units of battalion size and smaller. Target acquisition is not a problem. Forward observer teams, equipped with a Ground Vehicle Laser Locator Designator (GVLLD) and the Digital Message Device (DMD) are providing friendly artillery units with a multitude of small, non-persistent targets of opportunity. Location, size, shape, and orientation of these targets are being reported with "nearest meter"

accuracy. Artillery units have been directed to neutralize leading edge Soviet targets to generate command and control problems for the enemy and help to slow the momentum of the advance. Ammunition economy is critical.

Under circumstances such as those described above, it would be reasonable to fire single battery volleys at each target as it is reported. Combat neutralization of targets, as discussed in Chapter III (ten percent expected fractional target coverage) would adequately meet tactical requirements. The decision to treat variables, as discussed in the next section, was made with this tactical scenario in mind.

Observed Variables

There are several variables which define the conditions for an artillery attack which will be referred to in this paper as "observed variables." These observed variables are similar to control variables in the sense that they cause a change in the response variable as they themselves change in value. They are dissimilar to control variables in that they are not controlled by an operator in order to optimize the response variable. Instead they are "forced on the operator" by nature, the enemy, or by factors beyond his control such as logistical considerations. Once the observed variables have defined the circumstances for the attack, the operator should select the aiming point pattern to optimize the expected fractional damage to the target. The scope of the study is partially

defined by deciding which of these observed variables are to be held constant and which are to be varied over what levels. For this study, the observed variables were treated as follows:

Weapon System and Ammunition

One weapon system and type of ammunition was selected for the study. The simulated weapon system is a hypothetical medium howitzer with characteristics similar to the U. S. Army's 155mm, M109A1, Self Propelled Howitzer. The simulated ammunition is similar to the M107 conventional high explosive (HE) 155mm projectile.

Battery Size

Two, four, and six gun batteries are investigated as separate cases, each with it's own set of pattern options. Medium howitzers have traditionally been employed in four (8 in.) and six (155 mm) gun batteries. Two gun batteries and two gun fire missions from four and six gun batteries have been used extensively in counterinsurgency operations such as those in South Vietnam.

Number of Volleys

Only single volley time-on-target (TOT) missions were considered. As discussed in the tactical scenario, targets of opportunity are each attacked by a single battery volley. This is in keeping with current doctrine. "The greatest demoralizing effect on the enemy can be achieved by delivering a maximum number of rounds from many pieces in the shortest possible time and with adjustment" [8].

Nature of Target

A hypothetical soft target is simulated with a lethal area of 600 square meters. Field Artillery, firing conventional high explosive ammunition, is most effective against soft targets. Examples of soft targets include personnel and sensitive electronic equipment such as radar and mobile missile launch sites even when field artillery weapons are employed against hard targets (such as tanks) their principle effectiveness results from the production of casualities among accompanying infantry and from forcing the armored vehicles to "button up" to protect crews from becoming casualties. Damage to equipment from such an attack is generally incidental and considered to be a bonus effect.

Target Size, Shape and Orientation

Targets considered for this research are rectangular with one dimension running parallel to the direction of fire. SNOW'S QUICKIE has the apparent capability of evaluating circular targets, but this is done by first converting the circular target to a square of equal area and then evaluating the effectiveness for that configuration. The model will not accept a target that does not have one axis oriented in the direction of fire. No suitable simulation model was found that could evaluate targets which did not meet this orientation restriction. Although it would be desirable to treat targets oriented in any direction relative to the direction of fire, the development and verification of a new computer

model with such a capability was beyond the scope of this thesis.

For the six gun battery, targets of 5,000, 10,000 and 20,000 square meters were simulated. For the smaller two and four gun batteries, the sizes were reduced to 2,500 5,000, and 10,000 square meters. The shape of the targets were defined by the ratio of target length (range dimension) to target width (deflection dimension). Ten target shapes were simulated with ratios of 0.20, 0.25, 0.33, 0.40, 0.50, 1.00, 2,00, 3.00, 4.00, and 5.00 (Figure 8). Targets with length to width ratios outside the range of from 0.20 to 5.00 should be considered linear targets and attacked as such.

Target Location Error (TLE)

A target location error of zero meters was used for all targets. This corresponds to the following target acquisition sources: forward observer with Laser Range Finder, target area base, flash ranging, photo interpretation, and airborn infrared target location [11]. The same reference which identifies the above target acquisition sources as having a CEP of zero meters, also estimates the CEP of target location errors for less reliable sources. For example, current counter-battery radar is estimated to have a TLE CEP of 75 meters; sound-ranging a CEP of 150 meters; and such sources as POW reports, shell reports, and communication intelligence a TLE CEP of 300 meters. No estimate of the variance associated with these TLE accuracies is given, but it would be

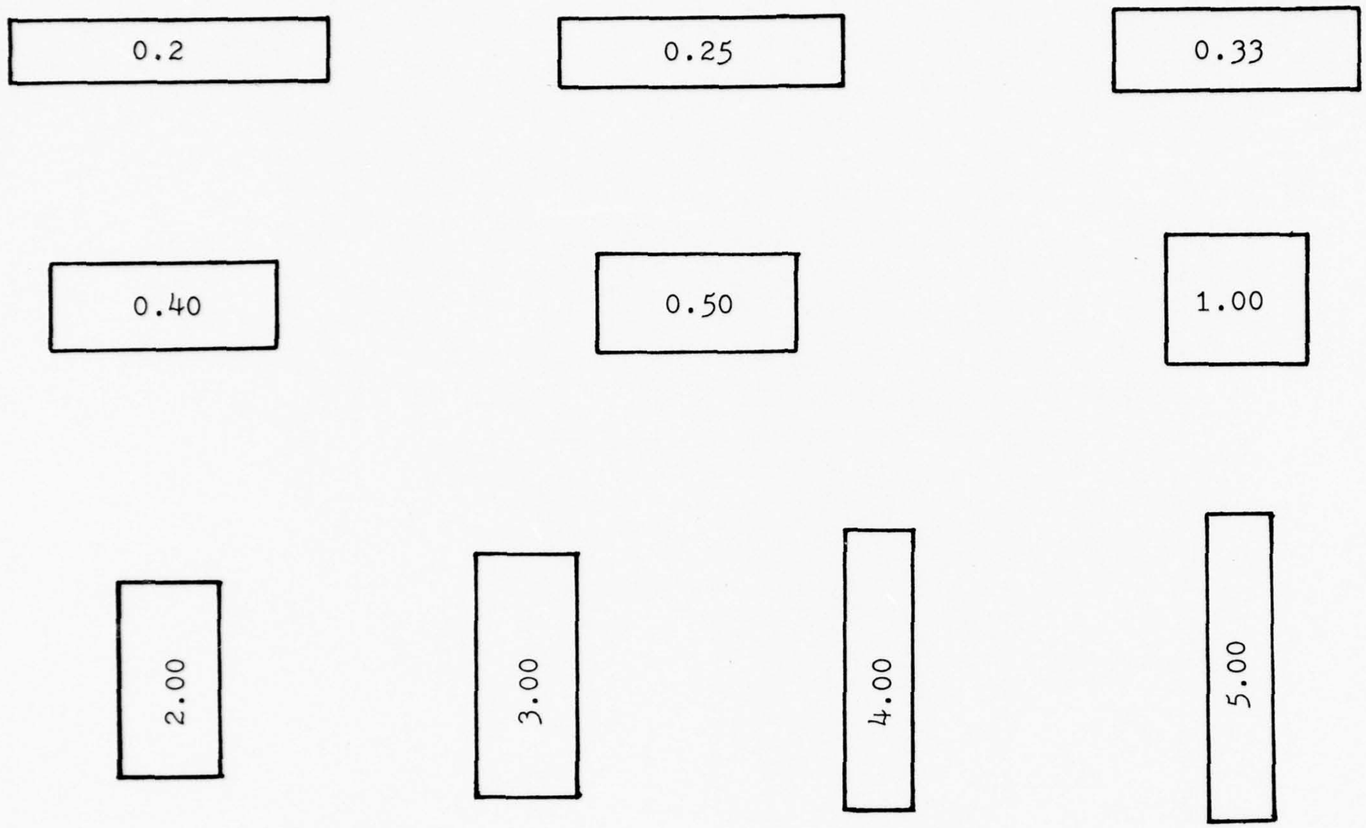


Figure 8. Target Shapes Defined By Length To Width Ratio

reasonable to interpret the unobserved attack on targets located by such means as little better than harassing fires.

Delivery Errors and Range

Delivery errors are divided into two categories: precision (round to round) errors and mean point of impact (occation to occasion) errors. Each weapon is assumed to be subject to a precision error in range and deflection, independent of the other weapons. By the Central Limit Theorem, the sum of a number of independent random variables can be expected to approach normality. Therefore, for artillery coverage problems, the precision error (also referred to as a ballistic error) is commonly assumed to have a noncorrelated bivariate normal distribution.

Mean point of impact (MPI) errors consist of target location error, survey error, meteorological error, and other factors which effect the entire volley of rounds and cause the mean point of impact of the burst pattern to be displaced. The MPI error distribution is also assumed to be bivariate normal.

Both forms of error are functions of time of flight and angle of fall which are in turn functions of range and the propellent charge used. Firing tables FT 155-AM-1 for M109A1 155 mm howitzer lists precision errors as probable error in range (PER) and probably error in deflection (PED) for each range and charge [13]. A charge selection table on page LXI of that reference highlights the charges that

provide the minimum PER for each range (Table 2). MET plus VE (meteorological plus velocity error) Mean Point of Impact errors which contain a zero target location error and are based on a four-hour-old meteorological message are tabulated in the JMEM, Basic Effects Manual, FM 101-60-17, for certain ranges and charges (Table 3) [12]. Using both tables as guides, a set of precision and MPI errors was defined for the hypothetical weapon system as a function of range (Table 4).

With the data in Figure 12, the single factor, (range) is used to define both precision and mean point of impact errors for the study. Three levels of range were used: 4,000, 8,000, and 12,000 meters for the six gun battery and 4,000, 6,000, and 8,000 for the four and two gun batteries.

Reliability of the Weapon System

A weapon system reliability factor of 0.95 was used throughout the study. Actual reliability factors for real weapon systems are classified.

Aiming Point Patterns

The aiming point patterns which were tested in the study are illustrated in Figure 9 through 12 and discussed in this section.

Six Gun Battery

The Battery Computer System (BCS) aiming point pattern for rectangular targets is a function of the long and short axis of the target. For six guns a three by two pattern is

Table 2. Precision Errors For 155 mm Howitzer[1]

Range (meters)	Powder Charge	Probable Error In Range	Probable Error In Deflection
4,000	5G[2]	10	3
5,000	5G	12	4
6,000	5G	15	5
7,000	5G	18	6
8,000	6W[3]	23	4
10,000	6W	26	6
12,000	7W	30	7

1 Selected data from FT 155-AM-1.

2 Green bag powder charge.

3 White bag powder charge.

Table 3. Met Plus VE Mean Point of Impact Error For 155 mm Howitzer[1]

Range (meters)	Powder Charge	Probable Error In Range	Probable Error In Deflection
4,000	3G[2]	40	11
4,000	3W[3]	40	11
6,000	3G	59	16
6,000	4G	56	15
8,000	6W	60	20
10,000	6W	80	30
12,000	7W	90	40

1 Selected data from FM 101-60-17. Met plus VE MPI error contains a zero target location error and is based on a four-hour-old meteorological message.

2 Green bag powder charge.

3 White bag powder charge.

Table 4. Delivery Errors For Hypothetical Weapon System

Range (meters)	Precision Probable Error		MPI Probable Error	
	Range	Deflection	Range	Deflection
4,000	10	3	40	11
5,000	12	4	45	13
6,000	15	5	50	15
7,000	18	6	58	18
8,000	23	4	60	20
10,000	26	6	80	30
12,000	30	7	90	40

used with three aiming points in the direction of the long axis. Two BCS patterns were tested, BCS Horizontal with three aiming points in the deflection direction and BCS Vertical with three aiming points in the range direction (Figure 9). The BCS strategy consists of the BCS Horizontal pattern for targets oriented with the long axis perpendicular to the direction of fire and the BCS Vertical pattern for targets with the long axis oriented parrallel to the direction of fire. It is not clear how the BCS strategy would apply to a square target, so both the horizontal and vertical versions were tested and the one producing the highest expected fractional coverage was ascribed to the BCS strategy.

The Lazy W pattern is static. For a 155 mm howitzer the aiming points are arranged as illustrated in Figure 9 with adjacent points fifty meters apart in both range and deflection directions. The ZERO pattern (Figure 9) represents salvo fire with all six rounds aimed at the center of the target.

Ten variable aiming point patterns were identified for the six gun battery (Figure 10). These patterns were chosen on a purely heuristic basis and represent, in the author's view, the number of ways six aiming points can be reasonably arranged to cover a rectangular target. Pattern number one is a linear distribution of aiming points perpendicular to the direction of fire. The distance between each pair of adjacent aiming points is equal to the control parameter d.

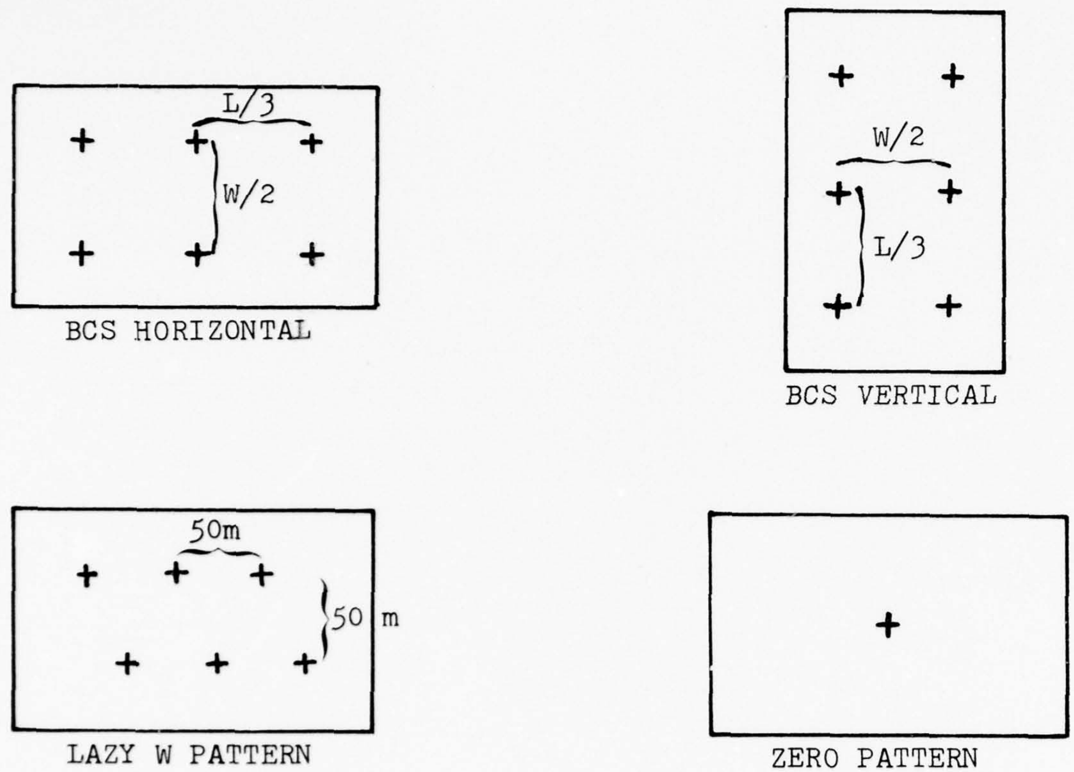


Figure 9. Aiming Point Patterns for Six Gun Battery, Page One

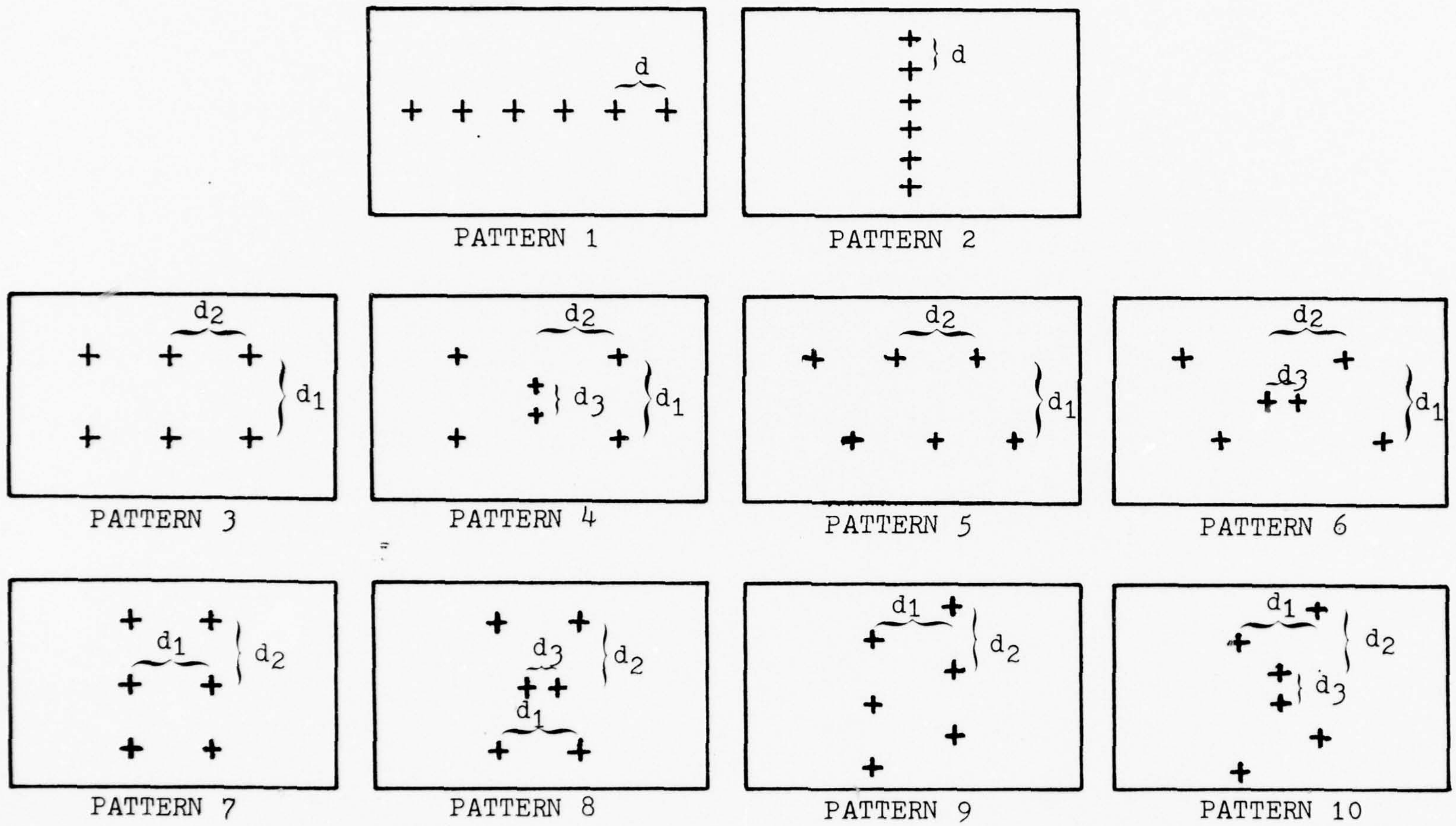


Figure 10. Aiming Point Patterns For Six Gun Battery, Page Two

Pattern number two is also linear, but parallel to the direction of fire. A golden section linear search technique was used to vary the value of d in the simulated attack of each of the ninety target missions. The search was terminated when the interval of uncertainty was reduced to less than one meter. In this manner an optimal value of d was found for patterns one and two against each target mission.

Pattern number three is a three by two arrangement similar to the BCS Horizontal Pattern. In this case, however, the distance between adjacent aiming points in both the range direction d_1 and the deflection direction d_2 are allowed to vary. In order to optimize pattern number three for each target mission, a cyclic coordinate search method was used with a golden section linear search in direciton d_1 and d_2. Pattern number four is a modification of number three in which the distance between the two center points are allowed to vary independently of the points at either end of the pattern. A three way cyclic coordinate search was used for this pattern in the three directions d_1, d_2, d_3 (Figure 10).

Pattern number is five is a variable form of the Lazy W with two control parameters, d_1 and d_2. It is modified in pattern number six to allow the center two aiming point to vary independently.

Patterns seven through ten are vertical versions of patterns three through six respectively.

Four Gun Battery

The four patterns are illustrated in Figure 11. The four gun BCS pattern, the ZERO pattern, and patterns, one, two and three are very similar to those for six guns. In addition to these, a diamond shaped pattern was tested (pattern four) for the four gun battery.

Two Gun Battery

There are not many ways to arrange two aiming points. A pattern was devised to represent the BCS strategy which is consistent with the BCS patterns for the four and six gun batteries. The ZERO pattern was tested with both aiming points at target center, and the two aiming points are separated in the deflection direction for pattern number one and in the range direction for pattern number two (Figure 12).

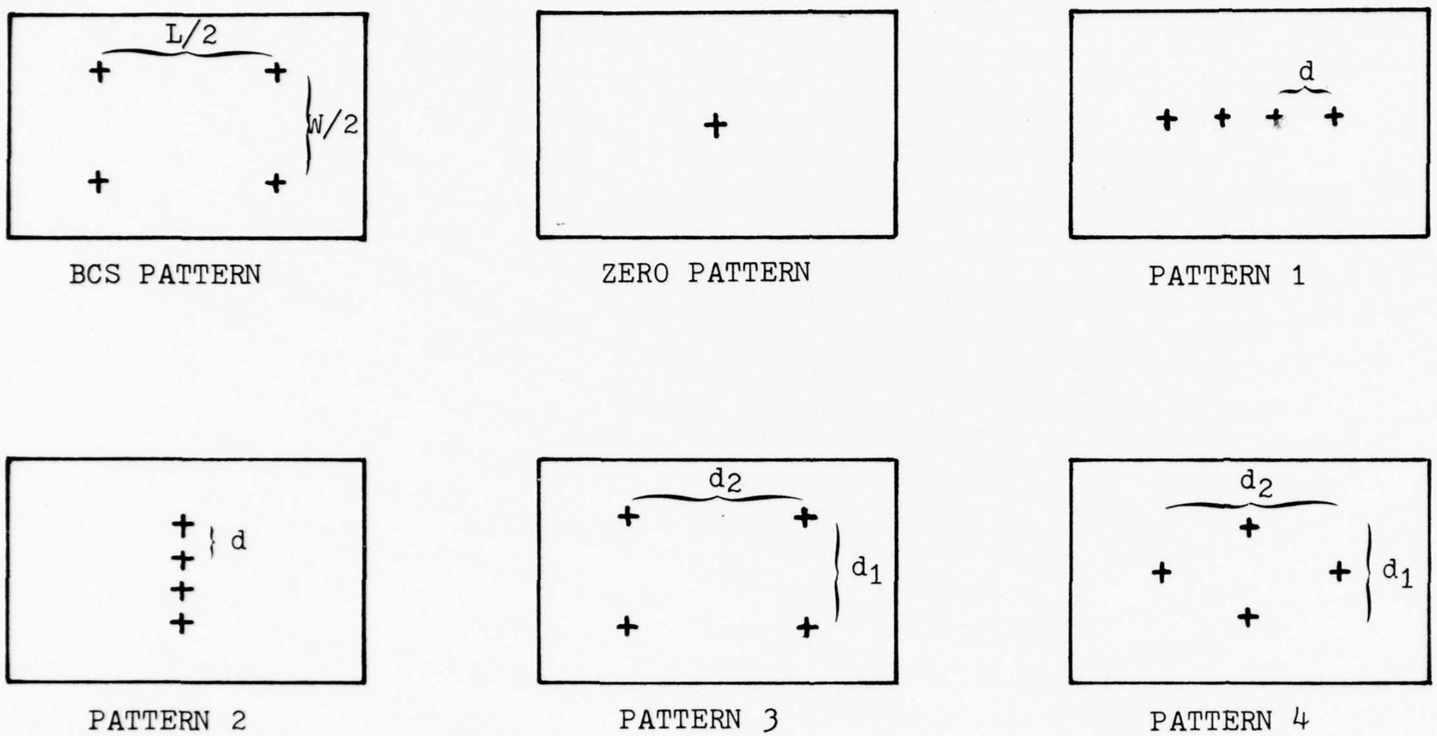


Figure 11. Aiming Point Patterns for Four Gun Battery

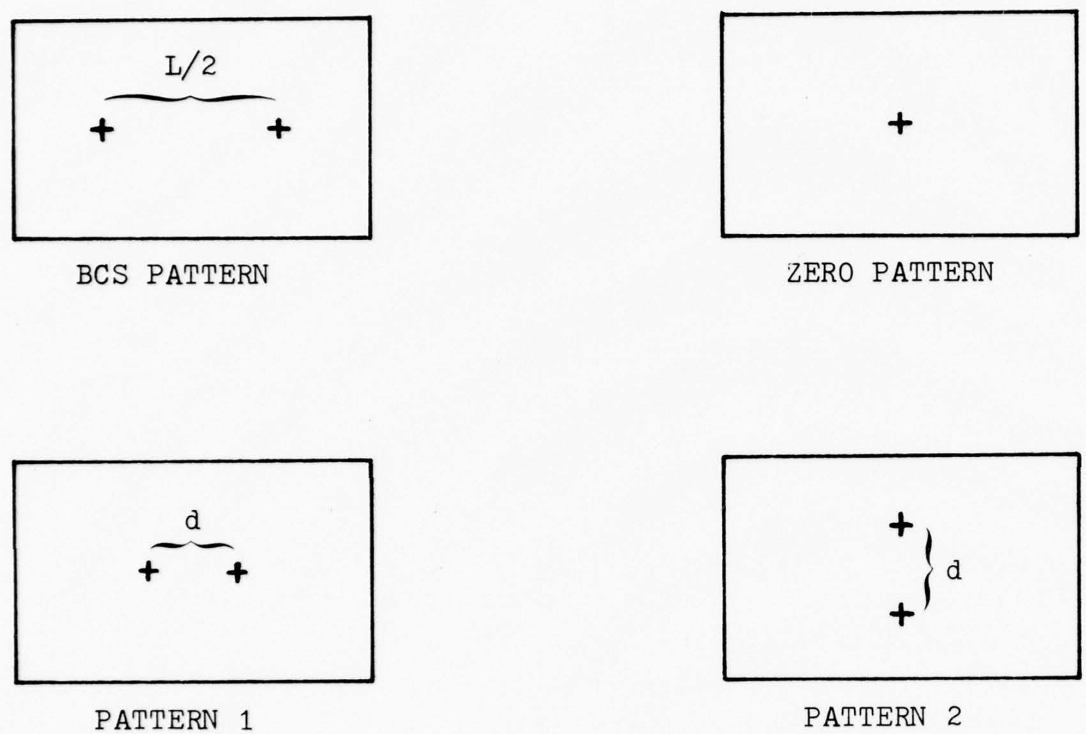


Figure 12. Aiming Point Patterns for Two Gun Battery

CHAPTER VI

RESULTS AND DISCUSSION

General

The primary result of this study is the development of a variable aiming point strategy for attacking area targets which produces near-optimal results in terms of expected fractional damage to the target. Expected fractional damage achieved by this strategy approached a twenty percent improvement over the aiming point strategy currently proposed for the BCS. Specific comparative data is given in the section "Comparison of Strategies" in this chapter.

The results of the simulated artillery attacks are tabulated in Appendix B. A discussion of the results for six, four, and two gun batteries follows in the next three sections. In each section equations are developed which model the relationship between target mission parameters and aiming point pattern control parameters. These equations form the basis of the variable aiming point strategy which is discussed in a later section.

In each instance the goal is to present as simple a model as possible which will achieve near optimal results. Near optimal is defined as greater than ninety-nine percent of the apparent optimal value. The primary factor which

permits use of the simple models described below is the very robust nature of the relationship between the control parameters for the variable aiming point patterns and the expected fractional coverage. In most cases a graph of expected coverage against pattern control parameters is very flat in the region of the optimal value. For example, Table 5 illustrates the changes in expected coverage caused by changes in the pattern control parameters d_1 and d_2 for a 10,000 square meter target with length to width ratio of 0.5, attacked from a range of 4,000 meters. The Lazy W and BCS expected coverage for this target is 5.88% and 10.66% respectively. With a large number of variables associated with firing artillery projectiles, the precise relationship between aiming points, expected coverage, and other factors is quite complex. The very fortunate "flat" nature of the aiming point/coverage relationship allows such simple models as linear and quadratic equations to be used. In all cases in this study, simplicity and utility will be given preference over mathematical rigor.

Six Gun Battery

For each target mission a comparison was made between the effects achieved by firing each pattern with its control parameters at optimal values (See Figures 13, 14, and 15). It appears that there is an "optimal configuration" or strategy for each target mission (size, shape, and error parameters) which produces optimal expected fractional damage.

Table 5. Expected Coverage For Different Values of d_1 and d_2

d_1 (range)	d_2 (deflection)	Expected Coverage* (percent)
16.8	1.5	11.72
34.3	1.5	11.80
34.9	1.5	11.75
34.3	6.4	11.79
34.3	10.3	11.78
34.3	16.6	11.73
34.3	26.9	11.56
34.3	43.6	10.88

* Six guns, pattern number three, 71 x 141 meter target, range 4,000 meters.

Each of the variable patterns (numbers one through ten) tends toward this "optimal configuration" within the limits of its variability. For example, large target dimensions and short ranges (shorter range resulting in better accuracy) favor dispersion of the aiming points (Figure 14). The "0" pattern was not competitive in such cases, since it is characterized by no dispersion of the aiming points whatsoever. The linear patterns, numbers one and two, did well in their own ends of the court; pattern one achieving good results for the wide targets with little depth, while pattern two (linear dispersion in range) scored better for the long targets with little width.

As the range increased, salvo fire takes over as the optimal strategy. The 5,000 and 10,000 square meter targets at 12,000 meters range can be best attacked by firing all rounds at target center (Figure 15). Each of the ten variable patterns collapses to the "0" pattern for these targets, resulting in the same effects on the target, except for minor differences due to round off.

Patterns three and seven produced the best overall results throughout the study. With the flexibility to disperse aiming points in either or both coordinate directions. These two patterns essentially represent an optimal strategy. For all practical purposes the two patterns are equally efficient. Of the ninety target missions simulated, in only two cases did the expected fractional damage for the two

patterns differ by more than one percent. For the 20,000 square meter target at 4,000 meter range, pattern three outperformed pattern seven by 1.2% for the 63 by 316 meter target and pattern seven beat pattern three by 1.5% against the 316 by 63 meter target.

The graphs in Figures 13, 14, and 15 are generally representative of the nine size/range combinations investigated.

Patterns four, five, six, eight, nine, and ten are not shown in the graphs. Each of these patterns approach the effects of three and seven in specific cases, but only as they imitate them. The increased complexity of these fancier patterns in no way enhanced their performance and none of them dominated in any of the cases investigated.

As mentioned above, patterns three and seven dominate the aiming point patterns investigated. Pattern three was selected as the basis for a variable aiming point strategy primarily because of its familiarity and intuitive appeal. The results for pattern seven are just as good, but pattern three looks more like the sheafs the artillery has been firing for years. In Figure 16 the range distribution parameter d_1 for pattern three is plotted against the target length (range dimension of the target). Values for d_1 which had obviously collapsed to zero were disregarded. At this point it was noted that only three significant data points were available for the 12,000 meter range, so three additional

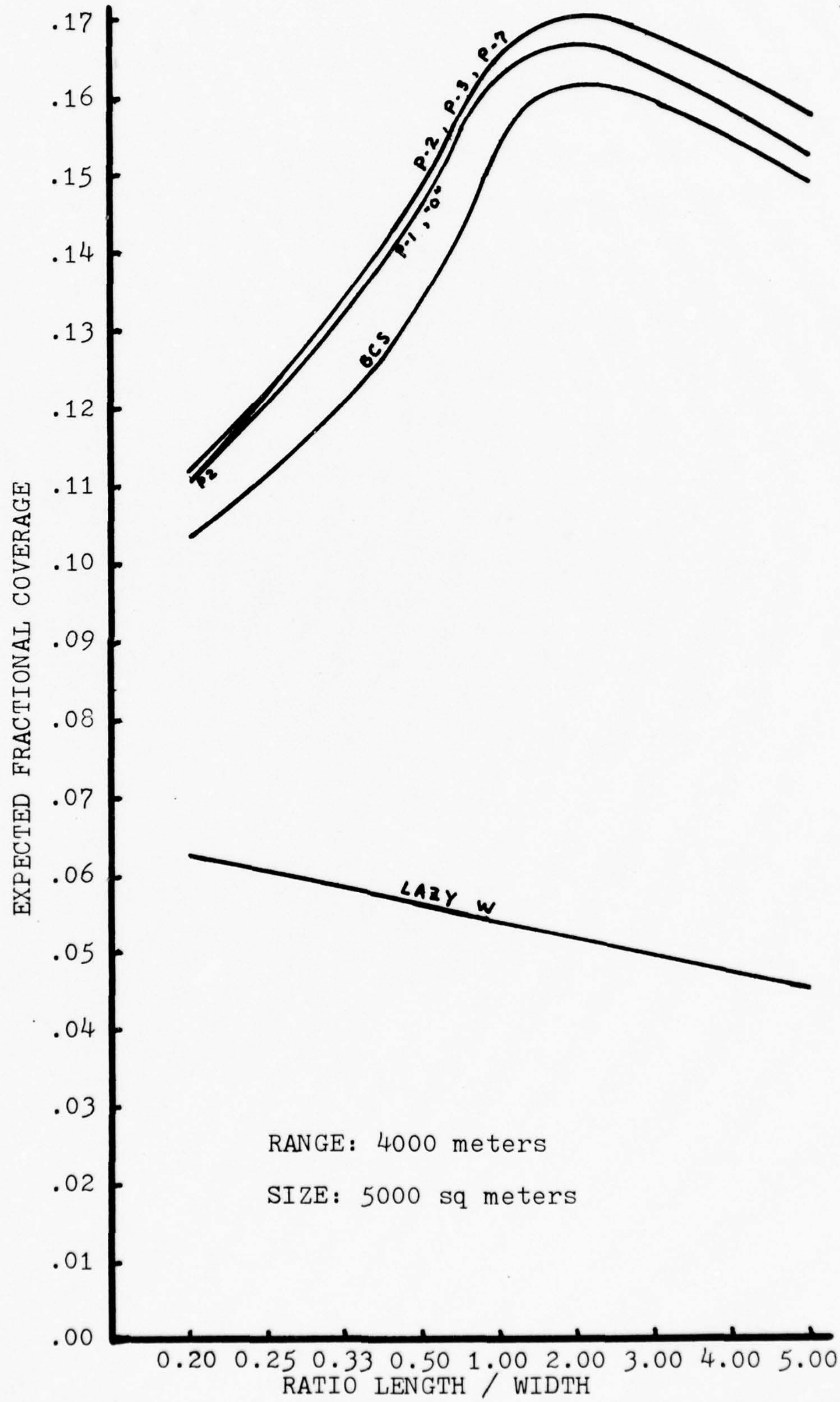


Figure 13. Pattern Comparison For Six Gun Battery, Page One

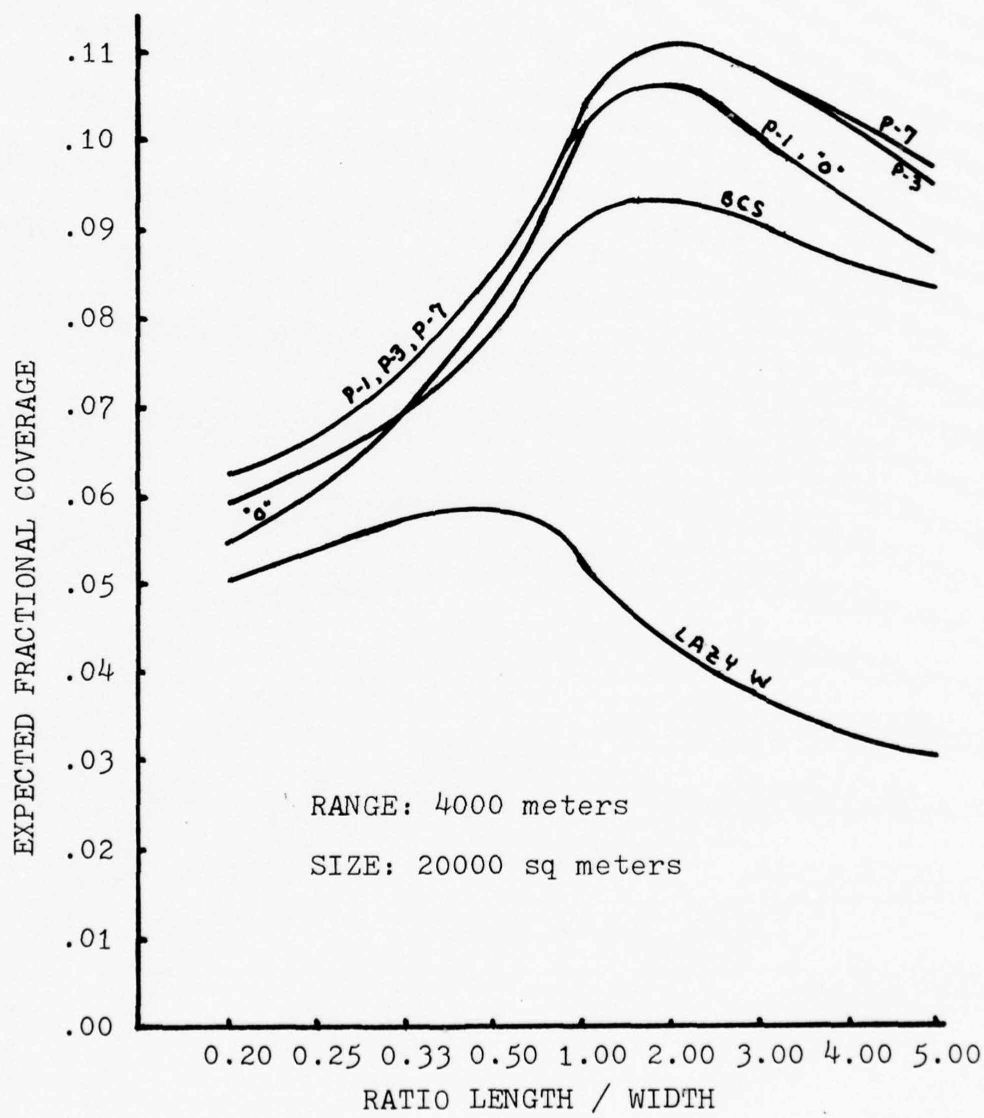


Figure 14. Pattern Comparison For Six Gun Battery, Page Two

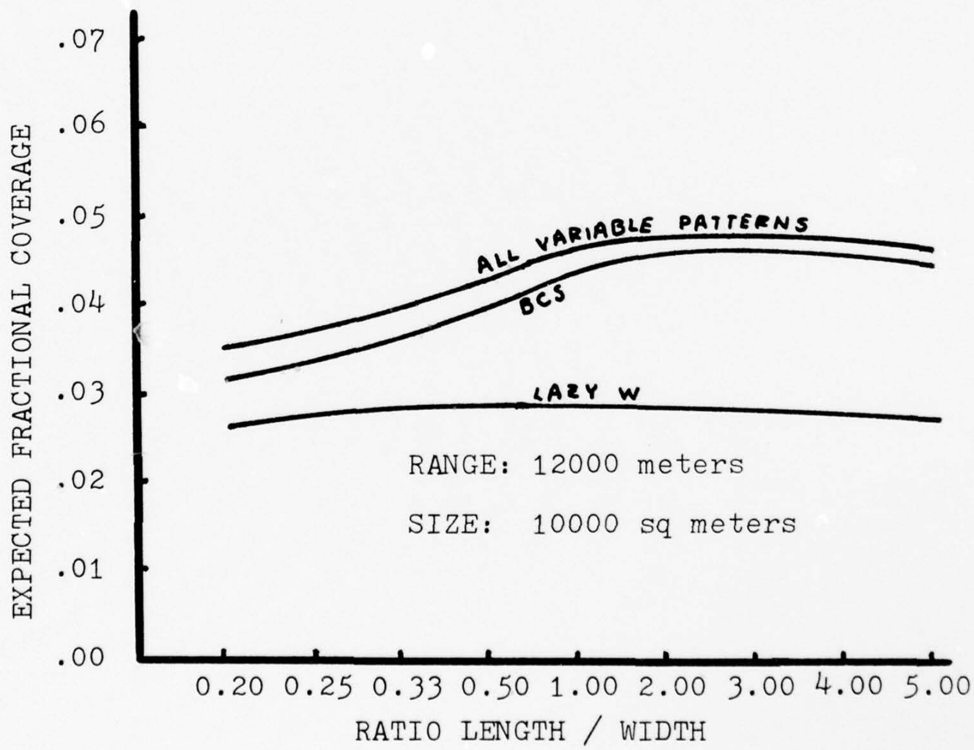


Figure 15. Pattern Comparison For Six Gun Battery, Page Three

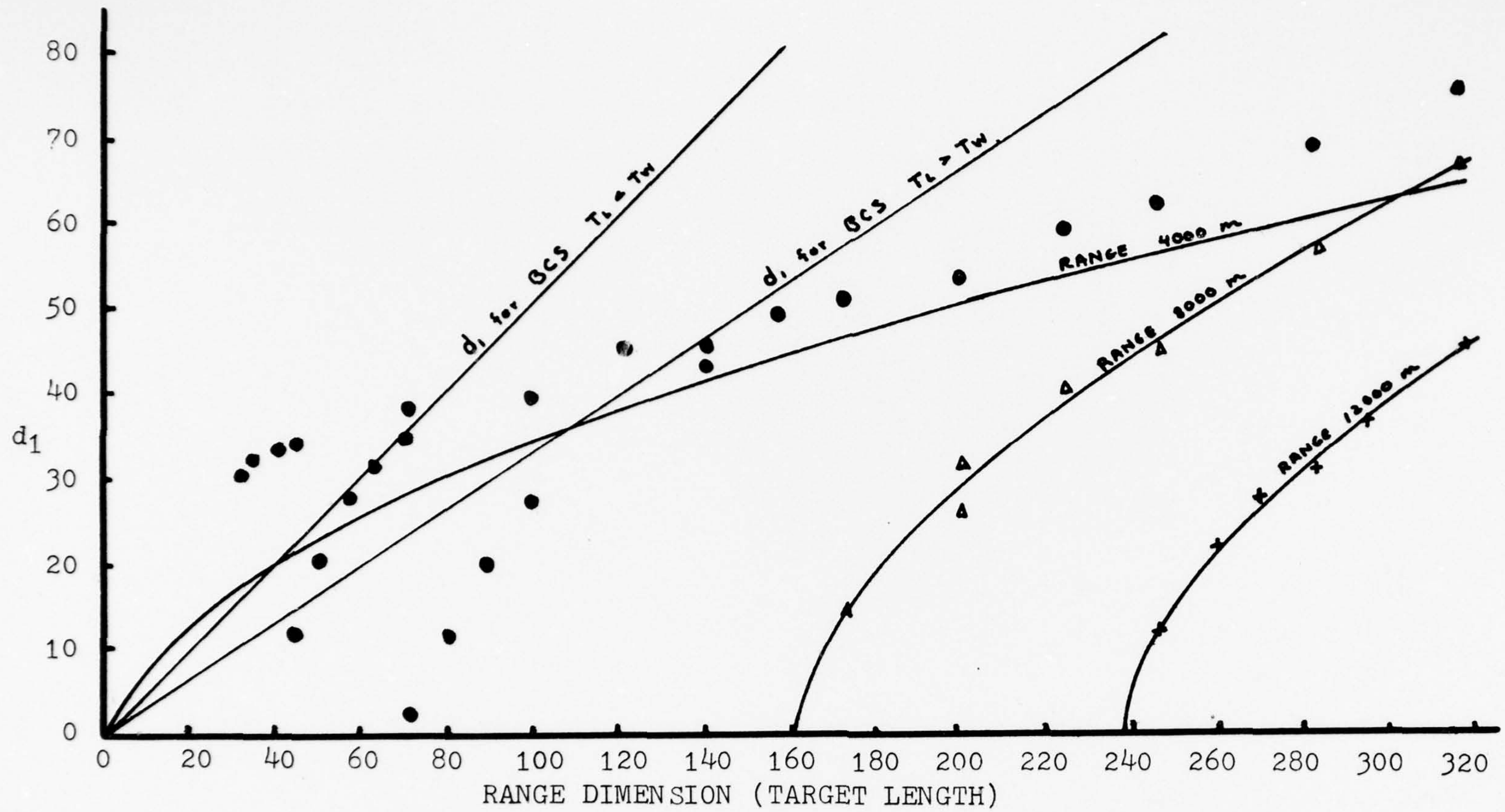


Figure 16. Relationship Between d_1 and Target Length for Six Gun Battery

tests were run at this range for targets with lengths of 260, 270 and 295 meters. Several equations which could be linearized by simple transformation were applied to this data. The power curve

$$y = ax^b$$

where $y = d_1$ = the range control parameter for the pattern

$x = T_i - c$ = target length - the x-intercept point

with suitable values for a, b, and c was found to fit the data points for th 8,000 and 12,000 meter ranges quite well. The linear form

$$\ln y = \ln a + b(\ln x)$$

was fit by simple linear regression. The value of c was varied to find the values for a, b, and c which resulted in the minimum sum of squares for the residuals (See Table 6).

The 4,000 meter range data was less cooperative. A plot of the data indicated three separate curves for the three target sizes. It appears that while d_1 is a function only of target length in most cases, it is significantly affected by the width of the target when the width exceeds a value of about one hundred and fifty meters. This

Table 6. Parameters For d_1 Equations*, Six Guns

Range (meters)	a	b	c	$SS_{Residuals}$
4,000	2.5752	0.5566	0	2865.86
8,000	3.2858	0.5921	161	20.15
12,000	3.2685	0.5952	237	4.97

* $d_1 = a(T_L - c)^b$

"interaction" of the effects on d_1 between length and width causes the 4,000 meter range data to split into three distinct curves. Fitting the data for each target size to the power curve in the same manner as for the 8,000 and 12,000 meter ranges produced the equation parameters in Table 7. Since both d_1 and target length represent real distances, negative values for these variables have little meaning. It was assumed that as the target length approaches zero, the value of d_1 will also approach zero. Adding the (0,0) point to the data for the 4,000 meter range, one equation was fit to the entire set of points. Although the residual sum of squares is very large, using this equation to determine d_1 values for all targets at the 4,000 meter ranges results in expected fractional damage within one percent of the optimal value for every data point available. Since the "near optimal" criterion is met, the overall equation is used to represent the 4,000 meter range data (Table 6).

The aiming point control parameter d_2 is plotted against target width in Figure 17. The power curve equation provided a very good fit for the d_2 curves for all three ranges (Table 8).

Since data had been determined for three ranges, quadratic equations were used to define the relationship between each of the parameters a, b, and c of the modified power curve

$$y = a(x - c)^b$$

Table 7. d_1 Equation Parameters At 4,000 Meter Range

Range (meters)	TGT SIZE (sq. meters)	a	b	c	$SS_{Residuals}$
4,000	5,000	8.4134	0.3402	-14	1.6
4,000	10,000	12.0565	0.2999	44	22.18
4,000	20,000	6.9775	0.4283	78	12.78
4,000	All Sizes	2.5752	0.5566	0	2865.86

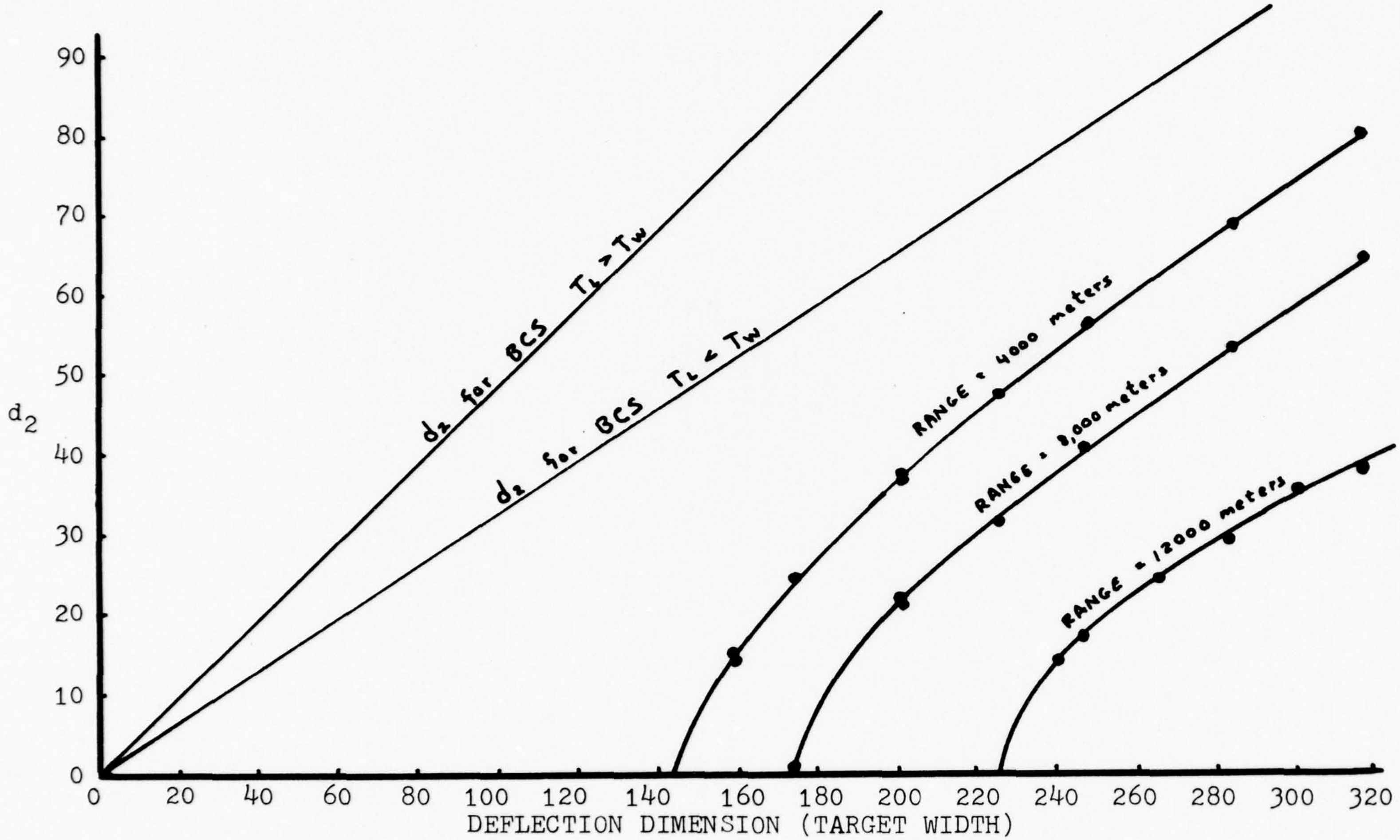


Figure 17. Relationship Between d_2 And Target Width For Six Gun Battery

Table 8. Parameters For d_2 Equations*, Six Guns

Range (meters)	a	b	c	$SS_{Residuals}$
4,000	2.3840	0.6812	143	0.9926
8,000	2.5452	0.6480	173	2.8332
12,000	2.9657	0.5754	225	0.5764

* $d_2 = a(T_W - c)^b$

for both the d_1 and d_2 equations. This provides a method for interpolating for d_1 and d_2 values at all ranges between 4,000 and 12,000 meters. Given the range to target R, the appropriate values for a_1, b_1, and c_1 for the d_1 equation and a_2, b_2, and c_2 for the d_2 equation can be calculated from:

$$a_1 = -0.0227\ R^2 + 0.4506\ R + 1.1367$$

$$b_1 = -0.0210\ R^2 + 0.0210\ R + 0.4887$$

$$c_1 = -2.6563\ R^2 + 72.1250\ R - 246.0$$

$$a_2 = 0.0081\ R^2 - 0.0569\ R + 2.4821$$

$$b_2 = -0.0012\ R^2 + 0.0065\ R + 0.6750$$

$$c_2 = 0.6875\ R^2 - 0.7500\ R + 135.0$$

Four Gun Battery

Data for the four gun battery displays characteristics similar to that of the six gun battery. Figures 18 through 20 illustrate the comparison between the effectiveness of the various patterns. These figures are representative of the nine size and range combinations simulated. While there is little difference in the effectiveness of the variable aiming point patterns, the BCS pattern is clearly less effective. The Lazy W pattern was not simulated for either the four or the two gun batteries. Pattern number three was

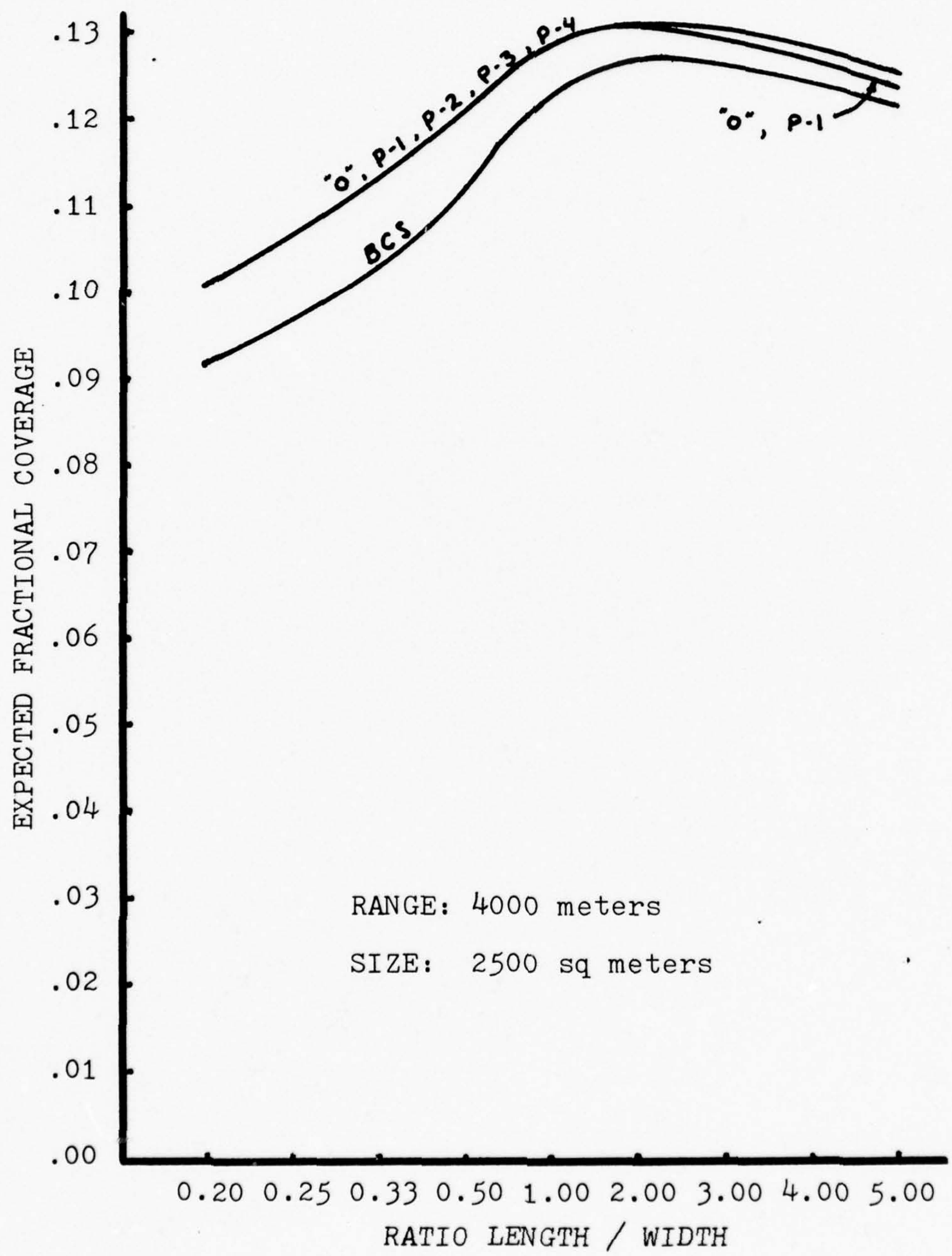


Figure 18. Pattern Comparison For Four Gun Battery, Page One

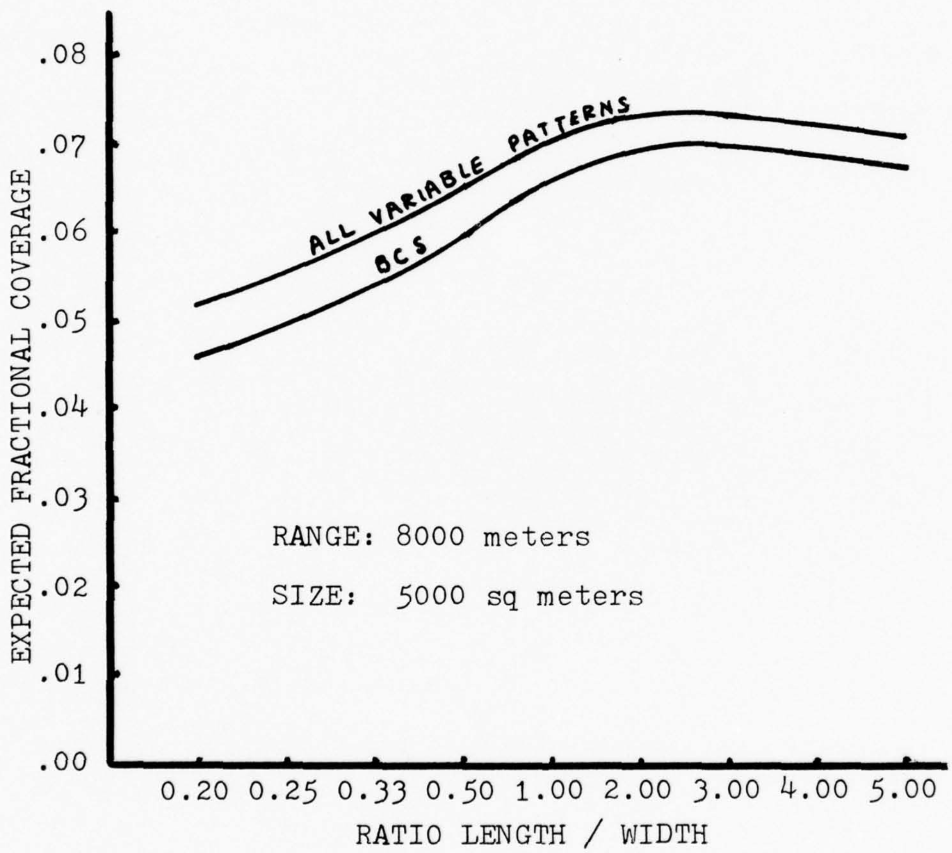


Figure 19. Pattern Comparison For Four Gun Battery, Page Two

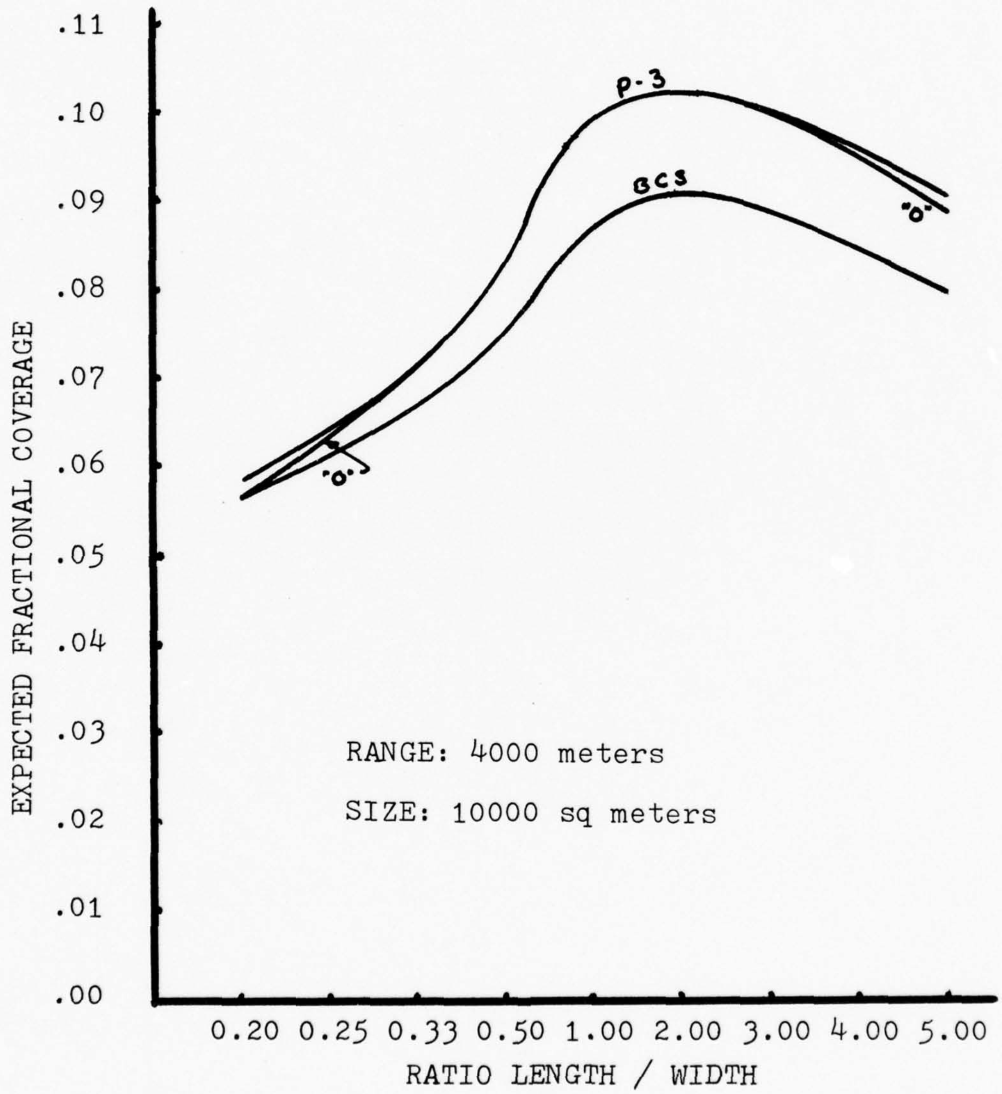


Figure 20. Pattern Comparison For Four Gun Battery, Page Three

generally dominant throughout the data set, if only marginally in most cases. The control parameters for pattern number three are plotted against the appropriate target dimensions in Figures 21 and 22. Although both sets of data could be fit with the modified power curve

$$y = (x-c)^b$$

as in the six gun case, the extremely robust nature of the relationship between d_1, d_2 and expected fractional damage allows for a straight line model for the four gun strategy. Simple linear regression provides the models:

$$d_1 = 0.1694T_L + 13.8107 \quad \text{, for range = 4,000mm}$$

$$d_1 = 0.2400T_L - 4.9231 \quad \text{, for range = 6,000mm}$$

$$d_2 = 0.8805T_W - 137.1306 \quad \text{, for ranges 4,000mm to 8,000mm}$$

where

T_L = target length

T_W = target width

As indicated in Figure 18 three of the data points were affected by interaction between target length and target width.

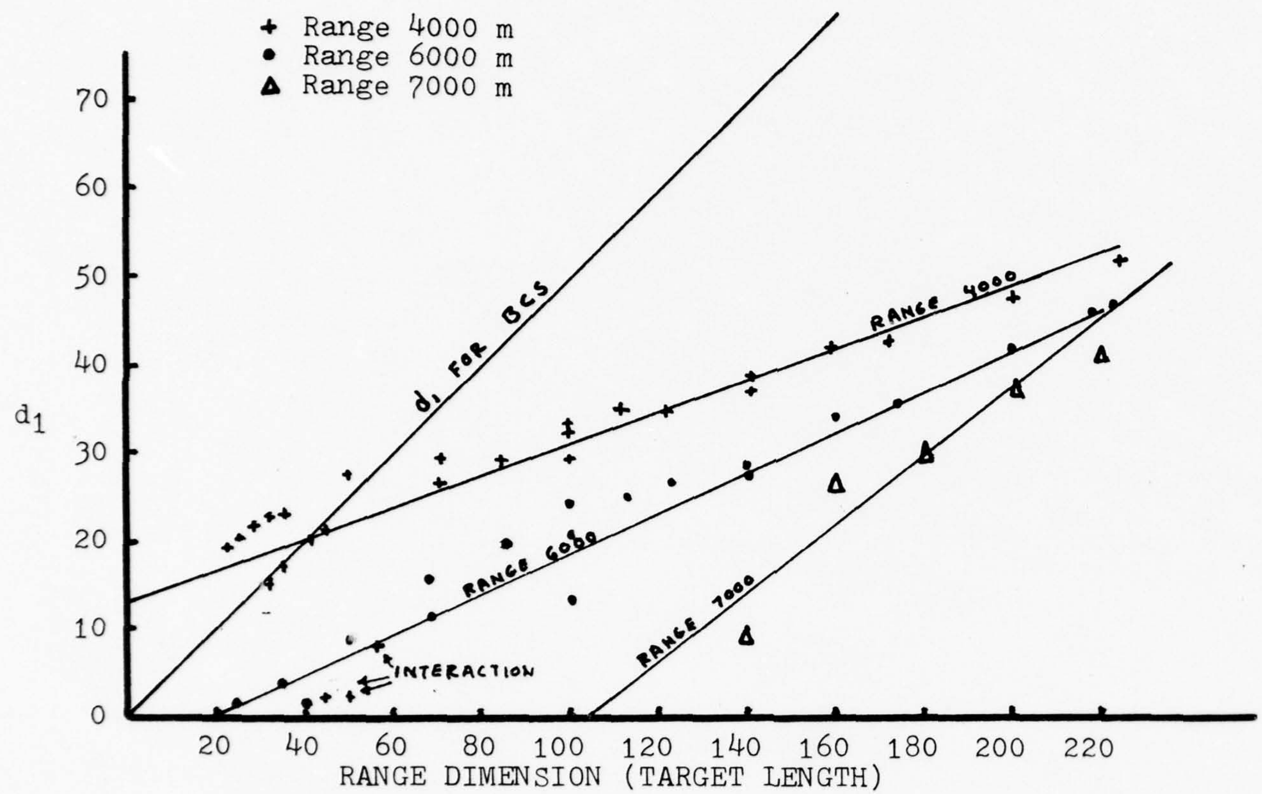


Figure 21. Relationship Between d_1 And Target Length For Four Gun Battery

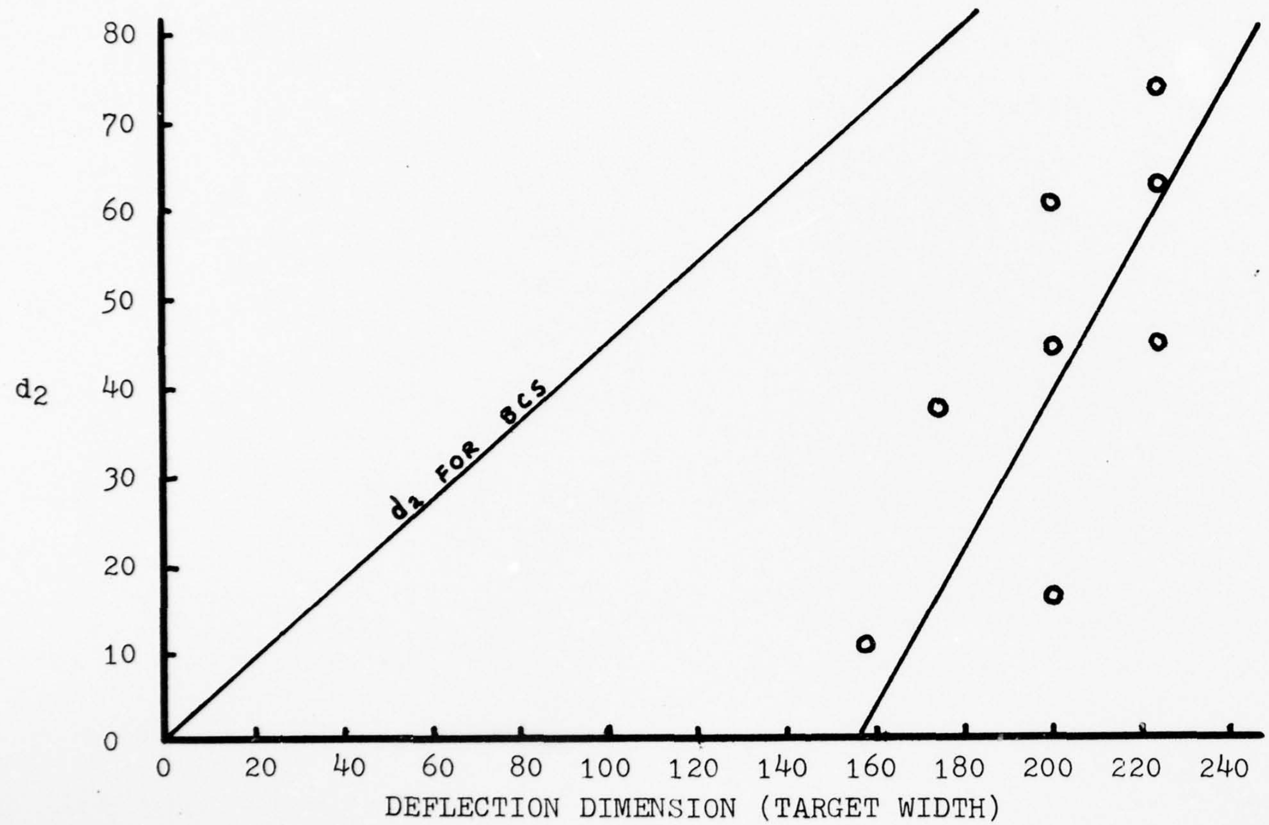


Figure 22. Relationship Between d_2' and Target Width For Four Gun Battery

As in the six gun case, the interaction occurs only for targets with widths greater than 150 meters and the degradation of expected fractional damage caused by this phenomenon is less than one percent for the most extreme case. The interaction problem was therefore ignored.

At a range of 8,000 meters, all d_1 values collapsed to zero. Supplemental data points were tested for a range of 7,000 meters to obtain the model:

$$d_1 = 0.3675\ T_L - 38.53$$

The correlation coefficients for the above four equations are:

d_1	, range 4,000:	0.9287
d_1	, range 6,000:	0.9755
d_1	, range 7,000:	0.9477
d_2	, all ranges:	0.8735

Quadratic equations were determined for interpolating values for the slope and y-intercept point for the d_1 equation corresponding to an intermediate range R.

$$d_1 = aT_L + b$$

where:

$$a = 0.0307R^2 - 0.2720R + 0.7658$$

$$b = -8.08R^2 + 71.4331R - 142.64$$

The d_2 relationship is approximated by the linear equation:

$$d_2 = 0.8805T_W - 137.1306$$

Two Gun Battery

The two gun volley is best fired at the target center. In nearly every case considered, the variable patterns all collapsed to the zero pattern for an optimal solution. The exception was for the 4,000 meter range (greatest accuracy) and for the target with the smallest length to width ratio. By attacking the 45 x 224 meter target with two rounds aimed at points 61 meters apart in deflection, a 1.01 percent improvement over the "0" pattern was realized. This was the only case out of the ninety tested in which the zero pattern was beat by more than one percent. The zero pattern is compared with a BCS pattern in Figures 23 and 24.

Variable Aiming Point Strategy

The variable aiming point strategy is defined in this section. It is designed for target situations which do not

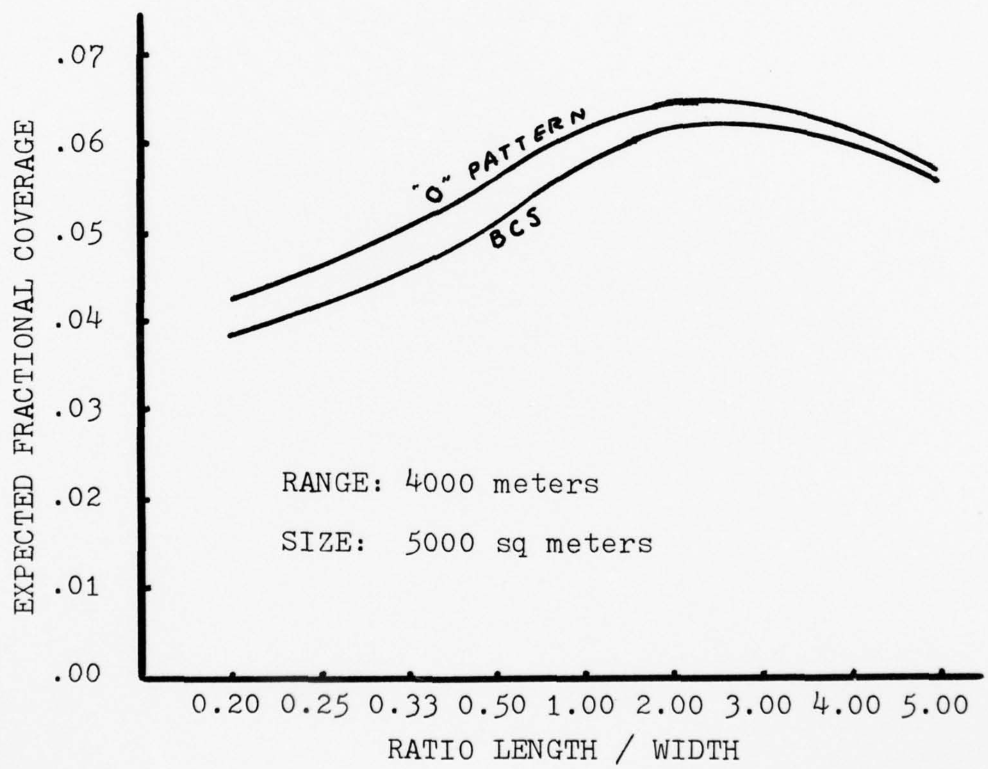


Figure 23. Pattern Comparison For Two Gun Battery, Page One

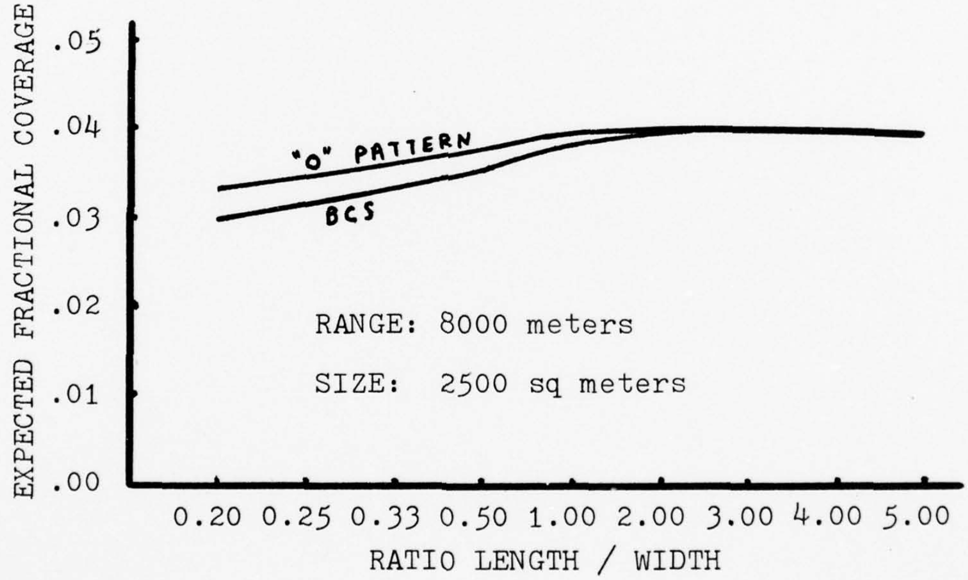


Figure 24. Pattern Comparison For Two Gun Battery, Page Two

exceed the limitations of the study established in Chapter V "Procedure." The strategy consists of firing salvo fire (both weapons aimed at target center) for the two gun volley. The four and six gun volleys are aimed using pattern number three for each battery size as described in Chapter V with the values of d_1 and d_2 determined by the equations below. These patterns are also illustrated in Figure 25. For the Six Gun Battery:

$$d_1 = a_1(T_L - c)^{b_2} \quad , \text{ if } T_L > c \quad , d_1 = 0 \quad , \text{ if } T_L \leq C$$

$$d_2 = a_2(T_W - c_2)^{b_2} \quad , \text{ if } T_W > c \quad , d_2 = 0 \quad , \text{ if } T_W \leq C$$

where:

d_1 = the distance between adjacent aiming points in the range direction.

d_2 = the distance between adjacent aiming points in the deflection direction.

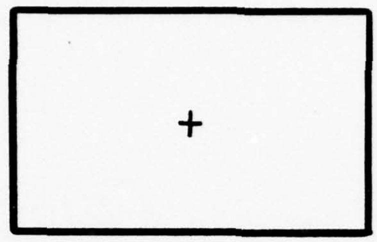
T_L = the target length in range direction.

T_W = the target width in deflection direction.

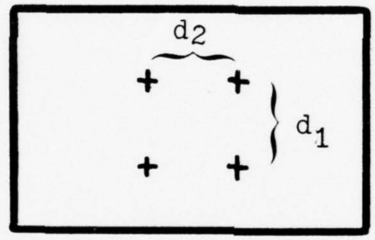
$a_1 = -0.0227R^2 + 0.4506R + 1.1367$

$b_1 = -0.0010R^2 + 0.0210R + 0.4887$

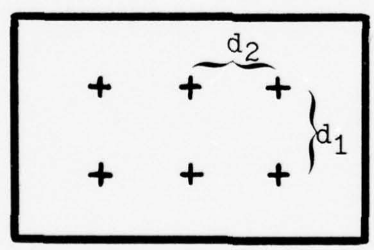
$c_1 = -2.6563R^2 + 72.1250R - 246.0$



TWO GUN PATTERN



FOUR GUN PATTERN



SIX GUN PATTERN

Figure 25. Patterns For Variable Aiming Point Strategy

$a_2 = 0.0081R^2 - 0.0569R + 2.4821$

$b_2 = -0.0012R^2 + 0.0065R + 0.6570$

$c_2 = 0.6875R^2 - 0.7500R + 135.0$

$R =$ Range from guns to target

For the Four Gun Battery:

$d_1 = a_1 T_L + b_1$

$d_2 = a_2 T_W + b_2$

where:

$T_L =$ the target length in range direction

$T_W =$ the target width in deflection

$a_1 = 0.0307R^2 - 0.2720R + 0.7658$

$b_1 = -8.08R^2 + 71.4331R - 142.64$

$a_2 = 0.8805$

$b_2 = -137{,}1306$

$R =$ Range from guns to target

Since d_1 and d_2 represnet real distances for both the six gun and the four gun cases, they cannot have negative values. If a negative value occurs for d_1 or d_2 for either size volley, the correct value is assumed to be zero.

Comparison of Strategies

Lazy W Strategy

The graphs of the Lazy W effects in Figures 18, 19, and 20 show the disadvantage of firing the same pattern regardless of the size, shape or orientation of the target. The results for the Lazy W are consistently below those of the BCS and the variable aiming point patterns. At the 4,000 meters range, the effects decrease for targets which are narrow in deflection and long in range. Significantly this is the shape that we could expect an enemy unit to present as it moves forward in a situation such as that described in the tacitical scenario in Chapter V. At the greater range of 12,000 meters the Lazy W curve is essentially flat, demonstrating its insensitivity to the target shape (Figure 15). It should be pointed out that current firing procedures do not call for firing the Lazy W pattern at all targets. A column of enemy personnel carriers with a length to width ratio of five, for example, could be attacked using special corrections with an aiming point pattern tailored to the specific target. Special corrections take a great deal of extra time to employ, however, and in a fast moving situation with many targets available,

the use of special corrections for all or most of them would not be a feasible solution.

BCS Strategy

The BCS pattern which changes with the size and shape of the target, produces expected fractional damage which in some cases is more than three times that of the Lazy W pattern. The results for this strategy are generally better for long narrow targets than they are for targets that are wide and shallow. This would be an advantage when defending against enemy units moving forward in column formation. Another advantage of the BCS strategy is its simplicity. Since the aiming point pattern depends only on the size, shape, and orientation of the target, there is no need to have delivery error distribution data in order to use this strategy. The price that is paid for this simplicity is sub-optimal effects. Since delivery error distributions do have an effect on the optimal placement of aiming points, a strategy which is independent of such information cannot be optimal. The parameters that control the distance between aiming points in the range direction (d_1) and in the deflection direction (d_2) for the BCS strategy are plotted in Figures 16, 17, 21 and 22 so that they may be compared with the respective parameters for the variable aiming point strategy.

As mentioned in an earlier chapter, two BCS patterns were evaluated: BCS Horizontal and BCS Vertical. An interesting result is that the BCS Vertical pattern outperformed

the BCS Horizontal pattern for all targets with low length to width ratios and the horizontal version dominated the vertical in some cases where the length to width ratio was three or greater. This implies that the BCS strategy could be improved by orienting the three by two pattern with three aiming points in the direction of the short axis and two in the direction of the long axis.

Variable Aiming Point Strategy (VAPS)

The Variable Aiming Point Strategy (VAPS) is the most flexible of those investigated and therefore best able to produce optimal results. Although slightly more complex than the BCS, it is very suitable for a computer application. The required delivery error distribution data can be determined and tabulated and/or programmed into computer memory. In Table 9, the control parameters d_1 and d_2 for both the BCS and VAPS, and the expected fractional coverage for Lazy W, BCS, and VAPS are shown for several selected targets. These targets were selected arbitrarily to indicate in a sample fashion a comparison of the three strategies. The targets were not selected by any statistically random process nor were they selected to intentionally favor a particular strategy. The comparison illustrated in this figure is generally representative of the entire set of circumstances considered in the study. The effects of the VAPS are also tabulated in Table 9 as a percent of the effects from the Lazy W and BCS patterns and as a percent of the optimal coverage.

Table 9. Comparison of Strategies

Number of Guns	Target Size	Target Shape	Range To Target	Aiming Point Control Parameters: BCS d_1	BCS d_2	VAPS d_1	VAPS d_2	Expected Fractional Coverage (Expressed as Percent): Lazy W	BCS	VAPS	Optimal	VAPS Coverage as % of: Lazy W	BCS	Optimal
6	5000	50x100	4	25	33	23	0	5.68	13.42	14.86	14.92	261.62	110.73	99.60
6	20000	200x100	4	67	50	49	0	4.26	9.36	11.12	11.13	261.03	118.80	99.91
6	15000	100x200	6	50	67	11	31	4.86	6.48	7.11	7.11	246.30	109.72	100.00
6	10000	200x50	6	67	25	46	0	3.86	10.38	11.37	11.39	294.56	109.54	99.82
6	7500	50x150	12	25	50	0	0	2.81	3.97	4.32	4.32	153.74	108.82	100.00
6	15000	150x100	12	50	50	0	0	2.76	4.33	4.58	4.58	165.94	105.77	100.00
4	2500	50x50	4	25	25	22	0	-	12.37	12.93	12.93	-	104.53	100.00
4	7500	50x150	5	25	75	21	0	-	6.67	7.28	7.28	-	109.15	100.00
4	10000	50x200	6	25	100	7	39	-	4.89	5.19	5.19	-	106.13	100.00
4	5000	100x50	6	50	25	19	0	-	8.94	9.39	9.39	-	105.03	100.00
4	1000	100x100	7	50	50	0	0	-	6.05	6.71	6.71	-	110.91	100.00
4	1000	200x50	8	100	25	23	0	-	5.92	6.47	6.48	-	109.29	99.85
2	2500	50x50	4	0	25	0	0	-	6.95	7.00	7.00	-	100.72	100.00
2	10000	50x200	6	0	100	0	0	-	2.54	2.72	2.71	-	107.09	100.00
2	10000	100x100	7	0	50	0	0	-	3.46	3.53	3.53	-	102.02	100.00
2	10000	200x50	8	100	0	0	0	-	3.14	3.39	3.39	-	107.96	100.00

Sensitivity

Several data points were tested outside the limits set for the study in order to gain some knowledge about the sensitivity of the results to these restrictions. Ten sample targets were run with a target location error of ten. Such a TLE corresponds to some of the early testing of some models of the laser range finder. As should be expected, the expected fractional coverage was degraded by the addition of this error. The aiming point parameters for optimal coverage, however, remained essentially unchanged for this small TLE. As discussed earlier, optimal aiming points on the basis of expected coverage have little meaning in the presence of large target location errors. If large target location errors are present some form of adjusting procedure is required for the artillery to be effective. The results of the TLE sampling is tabulated in Table 10.

The nature of target defined for this study has a lethal area of 600 square meters. Hard targets with significantly different lethal areas will be affected by artillery fire differently than soft targets. Targets with lethal areas which differ significantly should be studied thoroughly and are not sampled for this thesis. Minor deviations in the lethal area could result from such considerations as the amount of cover in the area (trees, or buildings) or the equipment, training, or pre-attack posture of personnel being attacked. Eight targets of different sizes were simulated,

Table 10. Sample Data For Change In Target Location Error

Target Size	Battery Size	Range (meters)	TLE = 0 d_1	TLE = 0 d_2	TLE = 0 Coverage	TLE = 10 d_1	TLE = 10 d_2	TLE = 10 Coverage
25x100	4 Guns	4,000	20.3	1.4	.10760	21.6	1.4	.10516
35x71	4 Guns	4,000	22.8	1.5	.12171	24.2	1.5	.11832
50x50	4 Guns	4,000	26.7	1.1	.12930	26.7	1.1	.12532
100x25	4 Guns	4,000	32.4	1.4	.12766	32.4	1.4	.12354
50x100	6 Guns	8,000	1.1	1.1	.09401	2.0	1.1	.09257
100x100	6 Guns	8,000	3.5	1.1	.09101	2.5	1.1	.08963
100x200	6 Guns	8,000	2.5	20.0	.06003	2.5	22.2	.05963
200x50	6 Guns	8,000	31.3	1.4	.09306	31.9	1.4	.09131
200x100	6 Guns	8,000	25.7	1.1	.08064	27.1	1.1	.07949
316x63	6 Guns	8,000	65.8	1.2	.07432	65.9	1.1	.07307

assuming a lethal area of 550 and 650 square meters. The largest resulting change in d_1 or d_2 for an optimal attack with pattern number three was less than one meter. The results are tabulated in Table 11.

Multiple volleys represent an entirely different problem than the single volley attack. Vehicular targets move and personnel "posture" (standing, prone, in foxholes, etc.) change in response to the first rounds of a multi-volley attack. Assumptions concerning the independence of error distributions become questionable for the case where each howitzer is firing several rounds. Multiple volley missions were not considered in the study.

Table 11. Sample Data For Change In Lethal Area

Target Size	Range (meters)	Lethal Area=550			Lethal Area=600			Lethal Area=650		
		d_1	d_2	Coverage	d_1	d_2	Coverage	d_1	d_2	Coverage
50x100	4,000	34.0	1.1	.14004	34.6	1.1	.14916	35.1	1.1	.15787
71x71	4,000	37.5	1.2	.15646	38.0	1.2	.16544	38.4	1.2	.17395
141x71	4,000	44.6	1.2	.13799	45.1	1.2	.14606	46.0	1.2	.15372
200x100	4,000	52.0	1.1	.10421	52.8	1.1	.11127	53.7	1.1	.11803
50x100	8,000	2.0	1.1	.08786	2.0	1.1	.09401	1.9	1.1	.09994
100x50	8,000	2.5	1.4	.09871	2.5	1.4	.10499	1.8	1.4	.11103
100x100	8,000	2.0	1.1	.08505	2.5	1.1	.09101	2.5	1.1	.09676
100x200	8,000	1.8	23.3	.05552	2.5	22.2	.06003	1.8	20.4	.06448

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

1. The Variable Aiming Point Strategy outlined in Chapter VI provides near optimal expected fractional coverage for the target conditions studied and substantially increased effectiveness over the Lazy W Pattern and the aiming point strategy currently proposed for the Battery Computer System for two, four, and six gun volleys.
2. The situation studied is the attack of an accurately located soft target characterized by a lethal area of 600 meters, a size of from 2,500 square meters to 20,000 square meters, rectangular in shape with one axis oriented in the direction of fire, and with a length to width ratio of from 0.20 to 5.00. This target is attacked at a range of from four to twelve kilometers with one volley from howitzers similar to the 155 mm howitzer M109A1, firing conventional high explosive ammunition. The weapon system has a reliability factor of 0.95 and delivery error parameters which conform to those enumerated in Table 4. Although hypothetical data was used in portions of this study to avoid security classification, the introduction of the actual classified data (such as lethal area and weapon system reliability factors) should not affect the validity of

the conclusions concerning the relationships between factors and the comparison of aiming point strategies. With the use of the actual data the specific values of the equation parameters may vary from those determined in this thesis.

3. The Lazy W aiming point pattern is consistently less effective than either the BCS Aiming Point Strategy or the Variable Aiming Point Strategy when employed against area targets under the circumstances studied in the thesis.
4. In addition to being significantly less effective than the other strategies, at relatively short range (4000 meters), the Lazy W pattern was characterized by decreasing effectiveness as the length to width target ratio increased. In contrast, both the BCS and Variable Aiming Point patterns demonstrated generally increasing effectiveness as the ratio increased. At a greater range (12,000) meters the Lazy W pattern achieved essentially the same target effects regardless of the shape or orientation of the target (See Figure 15.)
5. Delivery errors influence the optimal placement of aiming points for a given target situation, therefore a strategy involving aiming point patterns which vary as the delivery errors vary will be more effective than one that does not.
6. The relationship between the optimal values of d_1 and d_2 for the Variable Aiming Point Strategy and the expected

fractional coverage of the target are sufficiently robust (i.e. insensitive to minor deviations) to allow simple modeling procedures such as linear regression with first and second order equations to adequately model these relationships.

Recommendations

It is recommended that a study be initiated to verify and expand upon the conclusions of this study using actual data and field teating with artillery weapons. The goal of such an investigation should be the evaluation and further development of a variable aiming point strategy which takes full advantage of current knowledge of ballistics and delivery error distributions as well as current weapon evaluation modeling techniques; and that could be incorporated into the Battery Computer System.

Making use of the relationship between the range to the target and delivery errors for a specific set of powder charges, this study produced an aiming point strategy in which the parameter "range to target" represents the delivery error distributions. The models used in this strategy adequately estimate the optimal values for spacing between aiming points only if the assumed powder charges are used (i.e. only if the delivery errors remain properly associated with range.) Further study should be aimed at developing a strategy which involves the delivery error distributions directly. Such a strategy should

provide more accurate estimates of the d_1 and d_2 values and would be free of the limiting restriction to a specific set of power charges.

A further recommendation is that future studies expand the investigation of variable aiming point strategies to include the entire spectrum of weapon systems, ammunition types (both conventional and non-conventional), and target characteristics.

APPENDIX A

Input Parameters

This appendix contains the input parameters used in the computer program to generate the observations used in this thesis. The INPUT GUIDE beginning on line A22 of the computer program (see listing in Appendix C) contains input instructions for the model with descriptions for each variable.

The following values for input parameters were used for all observations:

I FLAG	0
I FLAG 2	12
NCASLEV	0
CASIN (I)	not used
NUM	1
N POST	0
NVS	1
NTLE	1
NN (1)	1
I POST (I)	not used
U1	8.
U2	8.
SU1	0.
SU2	0.
REL	0.95
DS	0.2
DP	0.2

DC	0.2
TLE (1)	0.
AALS	600
AALP	not used
AALC	not used
RRATS	2.0
RRATP	not used
RRATC	not used
DTYPE	P
EE1	not used
EE2	not used
WW1	not used
WW2	not used
CNB	not used
RELSUB	not used

The following values for input parameters were varied as indicated below:

N varied with battery size being simulated.

Two Gun Battery	2
Four Gun Battery	4
Six Gun Battery	6

NTS varied as requirements dictated, usually ran ten target sizes per computer run.

NRG	varied as requirements dictated, usually ran one range per computer run.
A(I), B(I)	the value zero was input for A(I) and B(I) in order to generate the ZERO Pattern for each target mission. Other values for these variables were generated in the subroutines according to the requirements for each aiming point pattern investigated.
AA3(I), AA4(I)	the values used for target length AA3 and target width AA4 are indicated for each target shape in the OUTPUT DATA in Appendix B.

Table A-1. Delivery Error Input Parameters

Range	DTYPE	PER	PED	MPIR	MPID
4,000m	P	10.	3.	40.	11.
5,000m	P	12.	4.	45.	13.
6,000m	P	15.	5.	50.	15.
7,000m	P	18.	6.	58.	18.
8,000m	P	23.	4.	60.	20.
10,000m	P	26.	6.	80.	30.
12,000m	P	30.	7.	90.	40.

APPENDIX B

Output Data

This appendix contains the output data which was generated by the computer program.

TWO GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS HORIZONTAL D	BCS HORIZONTAL COV	BCS VERTICAL D	BCS VERTICAL COV
.20	22 X 112	56.0	4.87	11.0	5.45
.25	25 X 100	50.0	5.19	12.5	5.78
.33	29 X 87	43.5	5.57	14.5	6.14
.40	32 X 79	39.5	5.82	16.0	6.35
.50	35 X 71	35.5	6.07	17.5	6.56
1.00	50 X 50	25.0	6.67	25.0	6.95
2.00	71 X 35	17.5	6.92	35.5	7.00
3.00	87 X 29	14.5	6.88	43.5	6.85
4.00	100 X 25	12.5	6.80	50.0	6.68
5.00	112 X 22	11.0	6.69	56.0	6.50

L/W RATIO	TGT SHAPE	ZERO COV	PATTERN 1 D	PATTERN 1 COV	PATTERN 2 D	PATTERN 2 COV
.20	22 X 112	5.46	1.6	5.46	2.0	5.46
.25	25 X 100	5.80	1.4	5.79	1.1	5.80
.33	29 X 87	6.16	1.2	6.16	1.6	6.16
.40	32 X 79	6.37	1.2	6.37	1.3	6.37
.50	35 X 71	6.58	1.1	6.58	2.0	6.58
1.00	50 X 50	7.00	1.4	7.00	1.8	7.00
2.00	71 X 35	7.10	1.5	7.10	1.5	7.10
3.00	87 X 29	7.01	1.2	7.01	2.4	7.01
4.00	100 X 25	6.90	1.1	6.90	2.7	6.90
5.00	112 X 22	6.76	1.5	6.76	3.1	6.76

TWO GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS HORIZONTAL		BCS VERTICAL	
RATIO	SHAPE	D	COV	D	COV
.20	32 X 158	79.0	3.88	16.0	4.22
.25	35 X 141	70.5	4.18	17.5	4.62
.33	41 X 122	61.0	4.57	20.5	5.08
.40	45 X 112	56.0	4.80	22.5	5.34
.50	50 X 100	50.0	5.10	25.0	5.64
1.00	71 X 71	35.5	5.84	35.5	6.23
2.00	100 X 50	25.0	6.19	50.0	6.29
3.00	122 X 41	20.5	6.15	61.0	6.07
4.00	141 X 35	17.5	6.02	70.5	5.81
5.00	158 X 32	16.0	5.82	79.0	5.54

L/W	TGT	ZERO	PATTERN 1		PATTERN 2	
RATIO	SHAPE	COV	D	COV	D	COV
.20	32 X 158	4.24	2.0	4.24	1.3	4.24
.25	35 X 141	4.63	1.7	4.63	1.5	4.63
.33	41 X 122	5.11	1.7	5.11	1.4	5.11
.40	45 X 112	5.37	1.6	5.37	1.6	5.37
.50	50 X 100	5.68	1.4	5.68	1.4	5.68
1.00	71 X 71	6.33	1.1	6.33	2.1	6.33
2.00	100 X 50	6.50	1.4	6.50	2.7	6.50
3.00	122 X 41	6.37	1.1	6.37	5.0	6.37
4.00	141 X 35	6.18	1.5	6.18	16.6	6.18
5.00	158 X 32	5.95	1.3	5.95	21.1	5.96

TWO GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 10000 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS HORIZONTAL D	BCS HORIZONTAL COV	BCS VERTICAL D	BCS VERTICAL COV
.20	45 X 224	112.0	2.96	22.5	3.01
.25	50 X 200	100.0	3.22	25.0	3.34
.33	58 X 173	86.5	3.55	29.0	3.78
.40	63 X 158	79.0	3.76	31.5	4.05
.50	71 X 141	70.5	4.02	35.5	4.38
1.00	100 X 100	50.0	4.73	50.0	5.09
2.00	141 X 71	35.5	5.08	70.5	5.16
3.00	173 X 58	29.0	5.00	86.5	4.89
4.00	200 X 50	25.0	4.81	100.0	4.61
5.00	224 X 45	22.5	4.57	112.0	4.35

L/W RATIO	TGT SHAPE	ZERO COV	PATTERN 1 D	PATTERN 1 COV	PATTERN 2 D	PATTERN 2 COV
.20	45 X 224	3.03	60.9	3.07	2.2	3.03
.25	50 X 200	3.37	43.0	3.39	1.4	3.37
.33	58 X 173	3.82	2.4	3.82	2.0	3.82
.40	63 X 158	4.11	3.2	4.11	2.2	4.11
.50	71 X 141	4.46	2.8	4.46	2.1	4.46
1.00	100 X 100	5.28	1.4	5.28	2.7	5.28
2.00	141 X 71	5.50	1.1	5.50	10.8	5.50
3.00	173 X 58	5.31	1.6	5.31	24.4	5.32
4.00	200 X 50	5.04	1.4	5.04	33.4	5.07
5.00	224 X 45	4.76	1.6	4.76	37.7	4.80

TWO GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS HORIZONTAL D	BCS HORIZONTAL COV	BCS VERTICAL D	BCS VERTICAL COV
.20	22 X 112	56.0	3.77	11.0	4.21
.25	25 X 100	50.0	4.01	12.5	4.44
.33	29 X 87	43.5	4.28	14.5	4.68
.40	32 X 79	39.5	4.45	16.0	4.82
.50	35 X 71	35.5	4.62	17.5	4.95
1.00	50 X 50	25.0	5.04	25.0	5.22
2.00	71 X 35	17.5	5.22	35.5	5.27
3.00	87 X 29	14.5	5.23	43.5	5.21
4.00	100 X 25	12.5	5.20	50.0	5.12
5.00	112 X 22	11.0	5.15	56.0	5.03

L/W RATIO	TGT SHAPE	ZERO COV	PATTERN 1 D	PATTERN 1 COV	PATTERN 2 D	PATTERN 2 COV
.20	22 X 112	4.22	1.6	4.22	2.8	4.22
.25	25 X 100	4.45	1.4	4.45	2.0	4.45
.33	29 X 87	4.69	1.2	4.69	2.2	4.69
.40	32 X 79	4.83	1.2	4.83	2.5	4.83
.50	35 X 71	4.97	1.1	4.97	2.0	4.97
1.00	50 X 50	5.25	1.4	5.25	2.5	5.25
2.00	71 X 35	5.34	1.5	5.34	2.1	5.34
3.00	87 X 29	5.31	1.2	5.31	1.2	5.31
4.00	100 X 25	5.26	1.1	5.26	2.0	5.26
5.00	112 X 22	5.19	1.5	5.19	2.2	5.19

TWO GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS HORIZONTAL		BCS VERTICAL	
RATIO	SHAPE	D	COV	D	COV
.20	32 X 158	79.0	3.03	16.0	3.36
.25	35 X 141	70.5	3.26	17.5	3.64
.33	41 X 122	61.0	3.56	20.5	3.98
.40	45 X 112	56.0	3.73	22.5	4.15
.50	50 X 100	50.0	3.96	25.0	4.36
1.00	71 X 71	35.5	4.51	35.5	4.78
2.00	100 X 50	25.0	4.80	50.0	4.87
3.00	122 X 41	20.5	4.81	61.0	4.77
4.00	141 X 35	17.5	4.76	70.5	4.63
5.00	158 X 32	16.0	4.66	79.0	4.47

L/W	TGT	ZERO	PATTERN 1		PATTERN 2	
RATIO	SHAPE	COV	D	COV	D	COV
.20	32 X 158	3.37	2.2	3.37	2.5	3.37
.25	35 X 141	3.65	1.9	3.65	2.0	3.65
.33	41 X 122	3.99	1.7	3.99	1.1	3.99
.40	45 X 112	4.18	1.4	4.18	1.6	4.18
.50	50 X 100	4.39	1.2	4.39	1.8	4.39
1.00	71 X 71	4.84	1.5	4.84	1.1	4.84
2.00	100 X 50	5.00	1.4	5.00	2.0	5.00
3.00	122 X 41	4.96	1.1	4.96	2.4	4.96
4.00	141 X 35	4.87	1.5	4.87	2.8	4.87
5.00	158 X 32	4.75	1.3	4.75	2.2	4.75

TWO GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 10000 SQUARE METERS

L/W	TGT	BCS HORIZONTAL		BCS VERTICAL	
RATIO	SHAPE	D	COV	D	COV
.20	45 X 224	112.0	2.34	22.5	2.44
.25	50 X 200	100.0	2.54	25.0	2.70
.33	58 X 173	86.5	2.80	29.0	3.05
.40	63 X 158	79.0	2.97	31.5	3.26
.50	71 X 141	70.5	3.18	35.5	3.51
1.00	100 X 100	50.0	3.77	50.0	4.03
2.00	141 X 71	35.5	4.11	70.5	4.20
3.00	173 X 58	29.0	4.12	86.5	4.05
4.00	200 X 50	25.0	4.03	100.0	3.86
5.00	224 X 45	22.5	3.90	112.0	3.67

L/W	TGT	ZERO	PATTERN 1		PATTERN 2	
RATIO	SHAPE	COV	D	COV	D	COV
.20	45 X 224	2.46	45.4	2.46	2.2	2.46
.25	50 X 200	2.72	12.4	2.72	2.5	2.72
.33	58 X 173	3.08	2.4	3.08	2.0	3.08
.40	63 X 158	3.30	3.2	3.30	3.1	3.30
.50	71 X 141	3.56	1.7	3.56	1.5	3.56
1.00	100 X 100	4.19	1.4	4.18	1.4	4.19
2.00	141 X 71	4.42	1.1	4.42	2.8	4.42
3.00	173 X 58	4.34	1.6	4.34	2.1	4.34
4.00	200 X 50	4.20	1.4	4.20	5.5	4.20
5.00	224 X 45	4.03	1.2	4.03	17.2	4.03

TWO GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W	TGT	BCS HORIZONTAL		BCS VERTICAL	
RATIO	SHAPE	D	COV	D	COV
.20	22 X 112	56.0	2.96	11.0	3.29
.25	25 X 100	50.0	3.12	12.5	3.44
.33	29 X 87	43.5	3.31	14.5	3.59
.40	32 X 79	39.5	3.43	16.0	3.68
.50	35 X 71	35.5	3.55	17.5	3.76
1.00	50 X 50	25.0	3.82	25.0	3.93
2.00	71 X 35	17.5	3.95	35.5	3.97
3.00	87 X 29	14.5	3.96	43.5	3.94
4.00	100 X 25	12.5	3.95	50.0	3.90
5.00	112 X 22	11.0	3.93	56.0	3.84

L/W	TGT	ZERO	PATTERN 1		PATTERN 2	
RATIO	SHAPE	COV	D	COV	D	COV
.20	22 X 112	3.29	1.6	3.29	2.8	3.29
.25	25 X 100	3.44	1.4	3.44	2.8	3.44
.33	29 X 87	3.60	1.2	3.60	1.6	3.60
.40	32 X 79	3.69	1.7	3.69	1.8	3.69
.50	35 X 71	3.77	1.1	3.77	2.0	3.77
1.00	50 X 50	3.95	1.4	3.95	2.5	3.95
2.00	71 X 35	4.02	1.5	4.02	2.1	4.02
3.00	87 X 29	4.01	1.2	4.01	2.4	4.01
4.00	100 X 25	3.99	1.4	3.99	1.2	3.99
5.00	112 X 22	3.96	1.5	3.95	1.5	3.96

TWO GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS HORIZONTAL		BCS VERTICAL	
RATIO	SHAPE	D	COV	D	COV
.20	32 X 158	79.0	2.40	16.0	2.70
.25	35 X 141	70.5	2.58	17.5	2.90
.33	41 X 122	61.0	2.81	20.5	3.13
.40	45 X 112	56.0	2.93	22.5	3.25
.50	50 X 100	50.0	3.10	25.0	3.39
1.00	71 X 71	35.5	3.49	35.5	3.67
2.00	100 X 50	25.0	3.70	50.0	3.74
3.00	122 X 41	20.5	3.72	61.0	3.69
4.00	141 X 35	17.5	3.71	70.5	3.61
5.00	158 X 32	16.0	3.66	79.0	3.52

L/W	TGT	ZERO	PATTERN 1		PATTERN 2	
RATIO	SHAPE	COV	D	COV	D	COV
.20	32 X 158	2.70	2.2	2.70	1.8	2.70
.25	35 X 141	2.91	1.9	2.91	2.0	2.91
.33	41 X 122	3.14	1.7	3.14	2.9	3.14
.40	45 X 112	3.27	1.6	3.27	2.2	3.27
.50	50 X 100	3.41	1.4	3.41	1.8	3.41
1.00	71 X 71	3.71	1.1	3.71	2.1	3.71
2.00	100 X 50	3.83	1.4	3.83	2.7	3.83
3.00	122 X 41	3.81	1.1	3.81	2.4	3.81
4.00	141 X 35	3.77	1.5	3.77	2.8	3.77
5.00	158 X 32	3.71	1.8	3.71	2.2	3.71

TWO GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS HORIZONTAL D	BCS HORIZONTAL COV	BCS VERTICAL D	BCS VERTICAL COV
.20	45 X 224	112.0	1.87	22.5	2.01
.25	50 X 200	100.0	2.03	25.0	2.22
.33	58 X 173	86.5	2.24	29.0	2.48
.40	63 X 158	79.0	2.37	31.5	2.64
.50	71 X 141	70.5	2.54	35.5	2.82
1.00	100 X 100	50.0	3.00	50.0	3.23
2.00	141 X 71	35.5	3.28	70.5	3.34
3.00	173 X 58	29.0	3.31	86.5	3.26
4.00	200 X 50	25.0	3.27	100.0	3.14
5.00	224 X 45	22.5	3.20	112.0	3.02

L/W RATIO	TGT SHAPE	ZERO COV	PATTERN 1 D	PATTERN 1 COV	PATTERN 2 D	PATTERN 2 COV
.20	45 X 224	2.02	13.9	2.02	3.1	2.02
.25	50 X 200	2.23	5.5	2.23	3.5	2.23
.33	58 X 173	2.50	2.4	2.50	2.0	2.50
.40	63 X 158	2.67	2.2	2.67	2.2	2.67
.50	71 X 141	2.86	2.8	2.86	1.5	2.86
1.00	100 X 100	3.30	1.4	3.30	2.7	3.30
2.00	141 X 71	3.48	1.1	3.48	2.8	3.48
3.00	173 X 58	3.46	1.6	3.46	3.4	3.46
4.00	200 X 50	3.39	1.8	3.39	4.0	3.39
5.00	224 X 45	3.29	1.2	3.29	3.0	3.29

FOUR GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS PATTERN D(1)	BCS PATTERN D(2)	BCS PATTERN COV	ZERO COV	PATTERN 1 D	PATTERN 1 COV
.20	22 X 112	11.0	56.0	9.20	10.14	1.3	10.13
.25	25 X 100	12.5	50.0	9.77	10.75	1.2	10.74
.33	29 X 87	14.5	43.5	10.44	11.40	1.0	11.39
.40	32 X 79	16.0	39.5	10.87	11.78	1.5	11.77
.50	35 X 71	17.5	35.5	11.31	12.14	1.4	12.13
1.00	50 X 50	25.0	25.0	12.37	12.88	1.5	12.87
2.00	71 X 35	35.5	17.5	12.78	13.04	1.1	13.03
3.00	87 X 29	43.5	14.5	12.67	12.86	1.5	12.85
4.00	100 X 25	50.0	12.5	12.47	12.65	1.3	12.64
5.00	112 X 22	56.0	11.0	12.20	12.40	1.1	12.40

L/W RATIO	PATTERN 2 D	PATTERN 2 COV	PATTERN 3 D(1)	PATTERN 3 D(2)	PATTERN 3 COV	PATTERN 4 D(1)	PATTERN 4 D(2)	PATTERN 4 COV
.20	8.2	10.14	19.0	1.5	10.15	19.8	1.5	10.14
.25	9.0	10.76	20.3	1.4	10.76	23.2	1.4	10.76
.33	9.3	11.41	21.9	1.2	11.42	25.9	1.2	11.41
.40	9.4	11.80	22.5	1.1	11.80	28.8	1.2	11.80
.50	10.3	12.17	22.8	1.5	12.17	31.5	1.5	12.17
1.00	11.1	12.92	26.7	1.1	12.93	34.6	1.1	12.92
2.00	12.9	13.10	29.1	1.2	13.11	38.7	1.2	13.10
3.00	13.6	12.95	33.8	1.0	12.96	42.0	1.0	12.95
4.00	14.3	12.76	32.4	1.4	12.77	44.5	1.4	12.75
5.00	14.7	12.53	34.6	1.2	12.54	46.3	1.2	12.52

FOUR GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	32 X 158	16.0	79.0	7.39	7.90	6.7	7.90
.25	35 X 141	17.5	70.5	7.94	8.63	1.1	8.63
.33	41 X 122	20.5	61.0	8.64	9.51	1.4	9.50
.40	45 X 112	22.5	56.0	9.04	9.98	1.3	9.97
.50	50 X 100	25.0	50.0	9.57	10.54	1.2	10.54
1.00	71 X 71	35.5	35.5	10.85	11.68	1.4	11.68
2.00	100 X 50	50.0	25.0	11.37	11.96	1.5	11.95
3.00	122 X 41	61.0	20.5	11.17	11.71	1.3	11.70
4.00	141 X 35	70.5	17.5	10.80	11.35	1.1	11.34
5.00	158 X 32	79.0	16.0	10.34	10.93	1.6	10.92

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	5.8	7.91	15.1	9.8	7.91	20.7	16.4	7.91
.25	7.2	8.64	17.5	1.0	8.64	22.6	1.0	8.64
.33	8.5	9.51	19.8	1.7	9.52	25.1	1.7	9.51
.40	8.2	9.99	21.2	1.5	9.99	25.8	1.5	9.99
.50	9.1	10.56	22.6	1.4	10.56	29.0	1.4	10.56
1.00	11.1	11.72	26.9	1.5	11.73	32.0	1.5	11.72
2.00	14.3	12.05	32.0	1.1	12.06	42.8	1.1	12.04
3.00	15.1	11.83	34.7	1.4	11.84	48.8	1.4	11.82
4.00	17.1	11.51	38.2	1.2	11.52	52.8	1.2	11.50
5.00	18.9	11.13	41.6	1.1	11.14	58.7	1.1	11.12

FOUR GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS PATTERN D(1)	BCS PATTERN D(2)	BCS PATTERN COV	ZERO COV	PATTERN 1 D	PATTERN 1 COV
.20	45 X 224	22.5	112.0	5.66	5.67	31.6	5.84
.25	50 X 200	25.0	100.0	6.14	6.30	24.3	6.40
.33	58 X 173	29.0	86.5	6.74	7.14	15.7	7.16
.40	63 X 158	31.5	79.0	7.11	7.67	6.4	7.67
.50	71 X 141	35.5	70.5	7.56	8.31	1.1	8.31
1.00	100 X 100	50.0	50.0	8.73	9.79	1.2	9.79
2.00	141 X 71	70.5	35.5	9.12	10.17	1.4	10.16
3.00	173 X 58	86.5	29.0	8.82	9.79	1.1	9.79
4.00	200 X 50	100.0	25.0	8.41	9.29	1.5	9.28
5.00	224 X 45	112.0	22.5	8.00	8.77	1.4	8.76

L/W RATIO	PATTERN 2 D	PATTERN 2 COV	PATTERN 3 D(1)	PATTERN 3 D(2)	PATTERN 3 COV	PATTERN 4 D(1)	PATTERN 4 D(2)	PATTERN 4 COV
.20	7.8	5.67	2.1	73.4	5.87	4.1	93.6	5.83
.25	6.9	6.30	2.0	59.8	6.42	6.5	73.4	6.39
.33	8.0	7.14	8.9	37.4	7.17	19.6	44.3	7.16
.40	8.1	7.68	20.2	1.2	7.68	25.9	13.3	7.68
.50	9.0	8.32	22.0	1.0	8.32	27.6	1.0	8.32
1.00	12.4	9.83	28.8	1.4	9.84	37.9	1.4	9.83
2.00	16.3	10.28	37.2	1.5	10.29	50.5	1.5	10.28
3.00	19.4	9.98	42.6	1.2	9.99	60.6	1.2	9.98
4.00	22.0	9.55	47.4	1.1	9.56	70.1	1.1	9.54
5.00	25.1	9.09	51.4	1.6	9.08	78.5	1.6	9.07

FOUR GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W RATIO	TGT SHAPE	BCS PATTERN D(1)	BCS PATTERN D(2)	BCS PATTERN COV	ZERO COV	PATTERN 1 D	PATTERN 1 COV
.20	22 X 112	11.0	56.0	7.21	7.96	1.3	7.96
.25	25 X 100	12.5	50.0	7.63	8.38	1.2	8.38
.33	29 X 87	14.5	43.5	8.12	8.83	1.0	8.83
.40	32 X 79	16.0	39.5	8.43	9.09	1.5	9.08
.50	35 X 71	17.5	35.5	8.74	9.34	1.4	9.33
1.00	50 X 50	25.0	25.0	9.47	9.85	1.5	9.84
2.00	71 X 35	35.5	17.5	9.78	10.01	1.1	10.01
3.00	87 X 29	43.5	14.5	9.75	9.95	1.5	9.94
4.00	100 X 25	50.0	12.5	9.66	9.85	1.3	9.85
5.00	112 X 22	56.0	11.0	9.53	9.73	1.1	9.73

L/W RATIO	PATTERN 2 D	PATTERN 2 COV	PATTERN 3 D(1)	PATTERN 3 D(2)	PATTERN 3 COV	PATTERN 4 D(1)	PATTERN 4 D(2)	PATTERN 4 COV
.20	1.5	7.96	2.2	1.5	7.96	3.2	1.5	7.96
.25	1.3	8.38	3.7	1.4	8.38	1.9	1.4	8.38
.33	1.9	8.83	2.6	1.2	8.83	3.9	1.2	8.83
.40	1.6	9.09	1.5	1.1	9.09	2.0	1.1	9.09
.50	1.5	9.34	3.2	1.5	9.34	4.8	1.5	9.34
1.00	2.8	9.85	8.2	1.1	9.85	2.0	1.1	9.85
2.00	6.9	10.01	16.3	1.2	10.01	20.0	1.2	10.01
3.00	8.9	9.95	20.0	1.0	9.95	25.1	1.0	9.95
4.00	9.3	9.86	24.0	1.4	9.86	28.8	1.4	9.86
5.00	10.4	9.74	24.9	1.2	9.74	32.3	1.2	9.74

FOUR GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	32 X 158	16.0	79.0	5.83	6.37	1.5	6.37
.25	35 X 141	17.5	70.5	6.26	6.91	1.1	6.91
.33	41 X 122	20.5	61.0	6.80	7.54	1.4	7.54
.40	45 X 112	22.5	56.0	7.11	7.88	1.3	7.88
.50	50 X 100	25.0	50.0	7.52	8.28	1.2	8.28
1.00	71 X 71	35.5	35.5	8.49	9.11	1.4	9.10
2.00	100 X 50	50.0	25.0	8.94	9.39	1.5	9.38
3.00	122 X 41	61.0	20.5	8.89	9.30	1.3	9.30
4.00	141 X 35	70.5	17.5	8.71	9.13	1.1	9.13
5.00	158 X 32	79.0	16.0	8.46	8.91	1.6	8.90

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	2.1	6.37	2.9	1.2	6.37	4.4	1.2	6.37
.25	2.0	6.91	3.2	1.0	6.91	3.2	1.0	6.91
.33	1.3	7.54	3.7	1.7	7.54	3.7	1.7	7.54
.40	1.4	7.88	4.1	1.5	7.88	2.1	1.5	7.88
.50	1.5	8.28	1.4	1.4	8.28	2.8	1.4	8.28
1.00	3.6	9.11	11.6	1.5	9.11	6.0	1.5	9.11
2.00	9.1	9.39	21.2	1.1	9.39	25.7	1.1	9.39
3.00	11.1	9.31	26.7	1.4	9.31	33.5	1.4	9.31
4.00	12.8	9.15	29.9	1.2	9.15	39.7	1.2	9.15
5.00	14.6	8.94	34.1	1.1	8.94	44.5	1.1	8.93

FOUR GUN BATTERY

RANGE TO TARGET : 6000 METERS
TARGET SIZE : 10000 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	45 X 224	22.5	112.0	4.51	4.66	26.0	4.72
.25	50 X 200	25.0	100.0	4.89	5.16	18.1	5.19
.33	58 X 173	29.0	86.5	5.37	5.83	2.3	5.83
.40	63 X 158	31.5	79.0	5.68	6.25	1.5	6.25
.50	71 X 141	35.5	70.5	6.05	6.74	1.1	6.74
1.00	100 X 100	50.0	50.0	7.06	7.89	1.2	7.89
2.00	141 X 71	70.5	35.5	7.53	8.31	1.4	8.30
3.00	173 X 58	86.5	29.0	7.42	8.16	1.1	8.16
4.00	200 X 50	100.0	25.0	7.16	7.89	1.5	7.88
5.00	224 X 45	112.0	22.5	6.85	7.57	1.4	7.57

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	1.9	4.66	2.9	62.0	4.73	2.9	77.5	4.72
.25	1.5	5.16	2.8	44.2	5.19	1.4	54.4	5.19
.33	2.0	5.83	3.2	1.1	5.83	4.9	1.1	5.83
.40	1.2	6.25	1.8	1.2	6.25	2.4	1.2	6.25
.50	2.5	6.74	4.0	1.0	6.74	4.0	1.0	6.74
1.00	4.7	7.89	13.5	1.4	7.89	13.5	1.4	7.89
2.00	11.7	8.32	28.9	1.5	8.32	35.8	1.5	8.32
3.00	15.7	8.19	35.4	1.2	8.19	47.0	1.2	8.19
4.00	18.1	7.94	41.7	1.1	7.95	57.0	1.1	7.94
5.00	20.3	7.65	47.4	1.6	7.65	65.2	1.6	7.64

FOUR GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 2500 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	22 X 112	11.0	56.0	5.72	6.31	1.3	6.30
.25	25 X 100	12.5	50.0	6.03	6.59	1.2	6.59
.33	29 X 87	14.5	43.5	6.38	6.89	1.0	6.89
.40	32 X 79	16.0	39.5	6.59	7.06	1.5	7.05
.50	35 X 71	17.5	35.5	6.81	7.22	1.4	7.22
1.00	50 X 50	25.0	25.0	7.29	7.56	1.5	7.55
2.00	71 X 35	35.5	17.5	7.49	7.68	1.1	7.68
3.00	87 X 29	43.5	14.5	7.48	7.66	1.5	7.65
4.00	100 X 25	50.0	12.5	7.43	7.61	1.3	7.61
5.00	112 X 22	56.0	11.0	7.36	7.56	1.1	7.55

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	1.1	6.31	2.2	1.5	6.30	1.6	1.5	6.31
.25	1.3	6.59	1.4	1.4	6.59	1.9	1.4	6.59
.33	1.5	6.89	1.8	1.2	6.89	2.6	1.2	6.89
.40	1.6	7.06	2.0	1.1	7.06	2.9	1.1	7.06
.50	1.5	7.22	2.2	1.5	7.22	2.2	1.5	7.22
1.00	1.5	7.56	2.0	1.1	7.56	2.8	1.1	7.56
2.00	1.4	7.68	2.7	1.2	7.68	2.0	1.2	7.68
3.00	1.0	7.66	2.0	1.0	7.66	1.5	1.0	7.66
4.00	1.2	7.61	2.5	1.4	7.61	1.8	1.4	7.61
5.00	1.3	7.56	2.0	1.2	7.56	2.7	1.2	7.56

FOUR GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	32 X 158	16.0	79.0	4.67	5.19	1.2	5.19
.25	35 X 141	17.5	70.5	5.00	5.58	1.4	5.58
.33	41 X 122	20.5	61.0	5.42	6.03	1.4	6.03
.40	45 X 112	22.5	56.0	5.66	6.26	1.3	6.26
.50	50 X 100	25.0	50.0	5.96	6.54	1.2	6.54
1.00	71 X 71	35.5	35.5	6.65	7.10	1.4	7.10
2.00	100 X 50	50.0	25.0	6.97	7.32	1.5	7.31
3.00	122 X 41	61.0	20.5	6.96	7.29	1.3	7.29
4.00	141 X 35	70.5	17.5	6.87	7.21	1.1	7.21
5.00	158 X 32	79.0	16.0	6.73	7.09	1.6	7.09

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	1.6	5.19	2.0	1.2	5.19	2.9	1.2	5.19
.25	1.1	5.58	2.2	1.0	5.58	2.2	1.0	5.58
.33	1.3	6.03	2.6	1.7	6.03	1.9	1.7	6.03
.40	1.4	6.26	1.6	1.5	6.26	2.9	1.5	6.26
.50	1.5	6.54	2.0	1.4	6.54	1.1	1.4	6.54
1.00	1.8	7.10	1.5	1.5	7.10	2.7	1.5	7.10
2.00	1.6	7.31	2.5	1.1	7.31	1.4	1.1	7.32
3.00	1.9	7.29	2.2	1.4	7.29	3.0	1.4	7.29
4.00	1.4	7.21	2.0	1.2	7.21	3.0	1.2	7.21
5.00	1.2	7.09	1.2	1.1	7.09	2.3	1.1	7.09

FOUR GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W	TGT	BCS PATTERN			ZERO	PATTERN 1	
RATIO	SHAPE	D(1)	D(2)	COV	COV	D	COV
.20	45 X 224	22.5	112.0	3.64	3.88	17.7	3.90
.25	50 X 200	25.0	100.0	3.94	4.29	5.0	4.29
.33	58 X 173	29.0	86.5	4.33	4.81	1.7	4.80
.40	63 X 158	31.5	79.0	4.57	5.12	1.2	5.12
.50	71 X 141	35.5	70.5	4.88	5.49	1.1	5.49
1.00	100 X 100	50.0	50.0	5.68	6.33	1.2	6.33
2.00	141 X 71	70.5	35.5	6.09	6.67	1.4	6.66
3.00	173 X 58	86.5	29.0	6.06	6.62	1.1	6.62
4.00	200 X 50	100.0	25.0	5.92	6.48	1.5	6.47
5.00	224 X 45	112.0	22.5	5.72	6.30	1.4	6.29

L/W	PATTERN 2		PATTERN 3			PATTERN 4		
RATIO	D	COV	D(1)	D(2)	COV	D(1)	D(2)	COV
.20	1.9	3.88	2.1	44.9	3.90	2.9	54.3	3.89
.25	1.5	4.29	1.4	15.1	4.29	2.8	15.1	4.29
.33	1.5	4.80	1.6	1.1	4.81	1.6	1.1	4.81
.40	1.6	5.12	2.4	1.2	5.12	1.3	1.2	5.12
.50	1.8	5.49	2.7	1.0	5.49	4.0	1.0	5.49
1.00	1.6	6.33	2.5	1.4	6.33	3.5	1.4	6.33
2.00	1.4	6.67	1.5	1.5	6.67	2.0	1.5	6.67
3.00	1.3	6.62	2.4	1.2	6.62	3.6	1.2	6.62
4.00	1.5	6.48	4.1	1.1	6.48	1.4	1.1	6.48
5.00	1.7	6.30	3.1	1.6	6.30	7.0	1.6	6.30

SIX GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W RATIO	TGT SHAPE		LAZY W COV	RCS HORIZONTAL D(1)	RCS HORIZONTAL D(2)	RCS HORIZONTAL COV	RCS VERTICAL D(1)	RCS VERTICAL D(2)	RCS VERTICAL COV	ZERO COV
.20	32	158	6.21	16.0	52.7	10.74	79.0	10.7	10.63	11.10
.25	35	141	6.08	17.5	47.0	11.12	70.5	11.7	11.39	12.11
.33	41	122	5.90	20.5	40.7	12.16	61.0	13.7	12.35	13.31
.40	45	112	5.80	22.5	37.3	12.68	56.0	15.0	12.91	13.95
.50	50	100	5.58	25.0	33.7	13.42	50.0	16.7	13.63	14.72
1.00	71	71	5.41	35.5	23.7	15.26	35.5	23.7	15.42	16.24
2.00	100	50	5.17	50.0	16.7	15.11	25.0	33.7	16.17	16.58
3.00	122	41	4.97	61.0	13.7	15.90	20.5	40.7	15.93	16.21
4.00	141	35	4.79	70.5	11.7	15.43	17.5	47.0	15.48	15.70
5.00	158	32	4.61	79.0	10.7	14.80	16.0	52.7	14.89	15.12

L/W RATIO	PATTERN 1 D	PATTERN 1 COV	PATTERN 2 D	PATTERN 2 COV	PATTERN 3 D(1)	PATTERN 3 D(2)	PATTERN 3 COV	PATTERN 4 D(1)	PATTERN 4 D(2)	PATTERN 4 D(3)	PATTERN 4 COV
.20	3.4	11.14	8.8	11.13	30.2	13.3	11.21	28.4	15.3	29.6	11.21
.25	1.4	12.11	9.7	12.01	32.1	1.5	12.22	31.1	1.5	31.5	12.22
.33	1.4	13.31	9.4	13.44	33.2	1.3	13.46	37.6	1.3	32.5	13.46
.40	1.3	13.95	9.8	14.10	33.9	1.2	14.12	33.4	1.2	33.2	14.12
.50	1.1	14.71	10.9	14.89	34.5	1.1	14.92	34.8	1.1	34.0	14.92
1.00	1.3	16.22	10.1	16.52	38.0	1.2	16.54	38.4	1.2	37.2	16.54
2.00	1.5	16.55	11.7	16.98	42.1	1.4	17.01	42.4	1.4	39.3	17.01
3.00	1.2	16.19	13.7	16.71	44.5	1.1	16.73	44.9	1.1	42.8	16.73
4.00	1.0	15.69	14.9	16.28	46.5	1.5	16.30	47.9	1.6	44.0	16.30
5.00	1.7	15.09	14.9	15.74	48.8	1.4	15.78	50.4	1.4	46.6	15.78

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W RATIO	TGT SHAPE	PATTERN 5 D(1)	D(2)	COV	PATTERN 6 D(1)	D(2)	D(3)	COV	PATTERN 7 D(1)	D(2)	COV
.20	32 X 158	29.6	1.1	11.16	30.9	1.1	30.9	11.17	30.7	16.5	11.20
.25	35 X 141	29.7	1.5	12.17	33.8	1.5	3.2	12.17	1.0	19.1	12.22
.33	41 X 122	31.6	1.3	13.40	39.6	1.3	1.9	13.41	1.7	20.2	13.45
.40	45 X 112	32.4	1.2	14.07	39.4	1.2	1.6	14.07	1.5	20.5	14.11
.50	50 X 100	33.5	1.1	14.87	41.6	1.1	1.4	14.87	1.4	21.0	14.90
1.00	71 X 71	37.5	1.2	16.49	46.3	1.2	1.5	16.49	1.1	23.2	16.53
2.00	100 X 50	40.0	1.4	16.95	51.5	1.4	1.4	16.95	1.4	25.9	17.00
3.00	122 X 41	44.0	1.1	16.69	55.9	1.1	1.7	16.68	1.1	27.8	16.72
4.00	141 X 35	46.0	1.6	16.24	57.9	1.6	1.0	16.24	1.5	29.4	16.30
5.00	158 X 32	48.2	1.4	15.73	61.5	1.4	1.2	15.74	1.3	31.8	15.78

L/W RATIO	PATTERN 8 D(1)	D(2)	D(3)	COV	PATTERN 9 D(1)	D(2)	COV	PATTERN 10 D(1)	D(2)	D(3)	COV
.20	27.3	14.6	37.3	11.20	29.6	1.4	11.09	60.3	1.4	47.1	110.60
.25	1.0	15.9	2.0	12.21	1.0	1.6	12.11	1.0	14.9	32.2	120.21
.33	1.7	19.4	2.2	13.44	1.7	1.1	13.31	1.7	14.5	33.9	13.44
.40	1.5	21.2	1.5	14.11	1.5	1.3	13.95	1.5	15.9	36.2	14.10
.50	1.4	20.5	1.4	14.90	1.4	1.4	14.72	1.4	15.5	39.6	14.90
1.00	1.1	23.2	1.5	16.53	1.1	1.2	16.24	1.1	18.0	39.5	16.53
2.00	1.1	24.7	1.1	17.00	1.4	20.1	15.93	1.4	21.4	34.5	16.99
3.00	1.1	28.6	1.4	16.72	1.1	24.6	16.68	1.1	24.1	36.9	16.72
4.00	1.5	28.4	1.2	16.29	2.0	27.9	16.26	1.5	25.4	30.6	16.28
5.00	1.3	32.8	1.1	15.78	1.3	30.7	15.75	1.3	27.5	30.9	15.77

SIX GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	45 X 224	6.12	22.5	74.7	7.97	112.0	15.0	8.21	7.97
.25	50 X 200	6.21	25.0	66.7	8.62	100.0	16.7	8.89	8.85
.33	58 X 173	6.15	29.0	57.7	9.46	86.5	19.3	9.74	10.03
.40	63 X 158	6.05	31.5	52.7	10.01	79.0	21.0	10.27	10.77
.50	71 X 141	5.88	35.5	47.0	10.66	70.5	23.7	10.90	11.65
1.00	100 X 100	5.33	50.0	33.3	12.39	50.0	33.3	12.53	13.67
2.00	141 X 71	4.79	70.5	23.7	13.01	35.5	47.0	13.13	14.14
3.00	173 X 58	4.43	86.5	19.3	12.61	29.0	57.7	12.77	13.60
4.00	200 X 50	4.13	100.0	16.7	12.04	25.0	66.7	12.23	12.89
5.00	224 X 45	3.87	112.0	15.0	11.45	22.5	74.7	11.64	12.16

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	22.1	8.38	9.8	8.03	11.6	47.5	8.40	1.6	47.5	25.8	8.41
.25	18.9	9.14	8.5	8.92	20.1	37.5	9.17	3.8	37.5	34.6	9.17
.33	13.2	10.15	8.9	10.11	27.6	24.6	10.20	11.9	24.6	35.5	10.20
.40	9.4	10.81	9.6	10.87	31.5	14.8	10.90	31.9	14.8	31.9	10.90
.50	2.1	11.65	10.1	11.78	34.3	1.5	11.80	36.0	1.5	32.6	11.80
1.00	1.1	13.67	11.2	13.92	38.9	1.1	13.94	40.3	1.1	36.5	13.94
2.00	1.3	14.13	13.3	14.59	45.1	1.2	14.61	45.1	1.2	45.6	14.61
3.00	1.0	13.59	16.3	14.20	50.4	1.0	14.21	50.2	1.0	50.4	14.21
4.00	1.5	12.87	17.5	13.63	54.3	1.4	13.61	54.4	1.4	54.3	13.61
5.00	1.3	12.14	19.6	13.01	58.4	1.3	12.96	79.4	1.3	16.9	13.00

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 4000 METERS
TARGET SIZE : 10000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	45 x 224	1.6	45.1	8.35	1.6	45.1	43.5	8.38	79.3	6.0	8.43
.25	50 x 200	29.5	1.4	8.89	1.1	34.0	48.9	9.16	66.0	10.7	9.20
.33	58 x 173	31.0	1.2	10.09	34.6	1.2	56.8	10.15	45.2	15.8	10.21
.40	63 x 158	31.5	1.1	10.85	37.6	1.1	40.0	10.86	28.6	18.4	10.89
.50	71 x 141	32.6	1.5	11.74	39.0	1.5	4.0	11.74	1.0	20.4	11.79
1.00	100 x 100	38.2	1.1	13.90	48.0	1.1	1.8	13.89	1.4	23.6	13.93
2.00	141 x 71	44.6	1.2	14.55	57.7	1.2	1.0	14.56	1.1	28.4	14.60
3.00	173 x 58	49.3	1.0	14.17	65.0	1.0	1.2	14.18	1.6	33.6	14.21
4.00	200 x 50	54.3	1.4	13.56	72.4	1.4	1.4	13.59	1.4	36.5	13.64
5.00	224 x 45	58.2	1.3	12.92	81.1	1.3	1.6	12.97	1.2	40.9	13.01

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	79.5	7.3	80.2	8.43	79.3	1.3	8.36	93.6	1.3	26.5	8.36
.25	66.5	10.4	68.0	9.20	65.4	1.4	9.11	75.1	1.4	35.4	9.11
.33	41.5	16.3	51.0	10.21	47.5	1.0	10.13	50.2	1.0	44.4	10.16
.40	24.0	17.7	36.2	10.89	31.3	1.1	10.78	30.7	1.1	49.9	10.85
.50	1.0	20.0	2.0	11.79	1.0	1.2	11.65	1.0	17.5	33.8	11.78
1.00	1.4	22.9	1.4	13.93	1.4	1.1	13.67	1.4	19.8	37.9	13.92
2.00	1.1	28.4	1.5	14.60	1.1	1.5	14.14	1.1	27.9	27.2	14.58
3.00	1.6	32.4	1.2	14.21	1.6	29.4	14.17	1.6	31.9	24.8	14.20
4.00	1.4	36.8	1.4	13.64	1.4	34.0	13.61	1.4	34.0	27.3	13.62
5.00	1.2	41.3	1.6	13.01	1.2	38.1	12.99	1.2	38.1	23.3	13.00

SIX GUN BATTERY

RANGE TO TARGET : 4000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	63 X 316	5.00	31.5	105.3	5.92	158.0	21.0	5.97	5.55
.25	71 X 283	5.36	35.5	94.3	6.39	141.5	23.7	6.49	6.13
.33	81 X 246	5.71	40.5	82.0	6.99	123.0	27.0	7.17	6.95
.40	89 X 224	5.82	44.5	74.7	7.39	112.0	29.7	7.59	7.52
.50	100 X 200	5.83	50.0	66.7	7.84	100.0	33.3	8.06	8.22
1.00	141 X 141	5.22	70.5	47.0	8.96	70.5	47.0	9.13	10.15
2.00	200 X 100	4.26	100.0	33.3	9.19	50.0	66.7	9.36	10.63
3.00	246 X 81	3.67	123.0	27.0	8.91	40.5	82.0	9.07	10.07
4.00	283 X 71	3.28	141.5	23.7	8.54	35.5	94.3	8.65	9.36
5.00	316 X 63	2.98	158.0	21.0	8.22	31.5	105.3	8.30	8.75

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	37.3	6.14	9.2	5.60	1.3	80.1	6.16	1.3	79.1	3.5	6.16
.25	31.5	6.69	9.6	6.19	2.0	68.9	6.71	1.5	67.9	2.7	6.71
.33	26.0	7.41	10.0	7.02	11.0	56.4	7.44	1.1	55.5	22.5	7.44
.40	22.1	7.90	9.4	7.60	19.5	47.5	7.93	4.3	47.5	33.7	7.94
.50	17.5	8.49	10.6	8.33	26.8	36.8	8.53	15.9	37.5	41.0	8.54
1.00	1.6	10.15	12.4	10.38	42.6	1.5	10.39	42.2	1.5	42.6	10.39
2.00	1.1	10.63	16.6	11.13	52.8	1.1	11.13	52.9	1.1	52.0	11.13
3.00	1.5	10.06	20.5	10.80	60.8	1.4	10.75	83.9	1.4	3.4	10.80
4.00	1.3	9.36	24.8	10.24	67.9	1.2	10.14	49.3	1.2	124.9	10.24
5.00	1.1	8.74	27.7	9.74	74.6	1.1	9.58	55.1	1.1	143.8	9.73

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 4000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	63 X 316	1.3	70.3	6.11	1.3	73.6	49.2	6.14	121.7	1.1	6.09
.25	71 X 283	1.5	62.8	6.66	1.5	62.8	59.4	6.68	107.1	2.2	6.68
.33	81 X 246	1.1	52.1	7.39	1.1	46.1	79.1	7.43	88.8	7.3	7.45
.40	89 X 224	33.1	1.5	7.57	1.2	38.1	84.8	7.93	78.9	11.4	7.96
.50	100 X 200	34.4	1.4	8.30	1.4	32.4	66.5	8.51	63.9	15.6	8.56
1.00	141 X 141	41.1	1.5	10.33	52.8	1.5	1.5	10.34	1.0	26.2	10.38
2.00	200 X 100	52.2	1.1	11.08	59.2	1.1	1.4	11.10	1.4	34.7	11.14
3.00	246 X 81	60.7	1.4	10.69	85.1	1.4	1.7	10.75	1.1	41.8	10.80
4.00	283 X 71	67.0	1.2	10.09	100.4	1.2	1.9	10.20	1.5	49.6	10.24
5.00	316 X 63	72.5	1.1	9.54	111.7	1.1	2.0	9.70	1.3	56.0	9.73

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	83.2	1.1	180.5	6.13	120.5	1.1	6.03	160.5	1.1	3.2	6.12
.25	82.2	1.2	148.5	6.69	106.1	1.2	6.61	137.8	1.2	5.7	6.66
.33	81.8	7.3	105.0	7.45	89.7	1.4	7.37	109.5	1.4	24.8	7.38
.40	76.4	11.4	83.1	7.96	78.5	1.5	7.87	91.6	1.5	37.7	7.88
.50	62.3	15.6	68.8	8.56	66.0	1.1	8.48	1.2	34.8	2.0	8.19
1.00	1.0	25.4	1.0	10.38	1.0	1.5	10.15	1.0	20.6	42.0	10.38
2.00	1.4	34.0	1.8	11.14	1.4	1.4	10.63	1.4	33.4	24.5	11.12
3.00	1.1	41.8	1.4	10.80	1.1	37.6	10.77	1.1	41.8	17.2	10.79
4.00	1.5	50.0	1.5	10.24	1.5	45.3	10.22	1.5	50.0	20.0	10.24
5.00	1.3	56.0	1.8	9.73	1.3	50.6	9.71	1.3	56.0	23.4	9.74

SIX GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	32 X 158	4.27	16.0	52.7	6.68	79.0	10.7	6.82	7.48
.25	35 X 141	4.26	17.5	47.0	7.16	70.5	11.7	7.30	8.04
.33	41 X 122	4.23	20.5	40.7	7.77	61.0	13.7	7.89	8.68
.40	45 X 112	4.21	22.5	37.3	8.11	56.0	15.0	8.23	9.01
.50	50 X 100	4.18	25.0	33.3	8.53	50.0	16.7	8.65	9.40
1.00	71 X 71	4.10	35.5	23.7	9.54	35.5	23.7	9.62	10.20
2.00	100 X 50	3.99	50.0	16.7	10.05	25.0	33.3	10.07	10.50
3.00	122 X 41	3.90	61.0	13.7	10.07	20.5	40.7	10.06	10.46
4.00	141 X 35	3.82	70.5	11.7	9.96	17.5	47.0	9.93	10.35
5.00	158 X 32	3.75	79.0	10.7	9.78	16.0	52.7	9.73	10.18

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	1.1	7.48	1.5	7.48	2.9	1.1	7.48	1.1	1.1	2.9	7.48
.25	1.6	8.03	1.0	8.04	1.6	1.5	8.04	1.2	1.5	1.6	8.04
.33	1.4	8.67	1.2	8.68	1.9	1.3	8.68	1.4	1.3	2.6	8.68
.40	1.3	9.01	1.3	9.01	2.9	1.2	9.01	1.6	1.2	4.1	9.01
.50	1.1	9.40	1.5	9.40	2.0	1.1	9.40	1.1	1.1	2.0	9.40
1.00	1.3	10.19	1.3	10.20	2.7	1.2	10.20	1.5	1.2	2.7	10.20
2.00	1.5	10.49	1.1	10.50	2.5	1.4	10.50	1.4	1.4	2.5	10.50
3.00	1.2	10.46	1.4	10.46	2.2	1.1	10.46	1.7	1.1	2.2	10.46
4.00	1.0	10.34	2.1	10.35	4.4	1.6	10.34	1.0	1.6	4.4	10.34
5.00	1.5	10.17	1.1	10.18	7.8	1.4	10.18	1.2	1.4	5.0	10.18

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	32 X 158	1.1	1.1	7.48	1.1	1.1	2.0	7.48	2.3	1.9	7.48
.25	35 X 141	1.2	1.5	8.04	1.2	1.5	2.2	8.04	1.5	2.1	8.04
.33	41 X 122	1.4	1.3	8.68	1.4	1.3	1.9	8.68	1.7	1.5	8.68
.40	45 X 112	2.1	1.2	9.01	1.6	1.2	2.1	9.01	1.5	1.3	9.01
.50	50 X 100	1.4	1.1	9.40	1.1	1.1	2.0	9.40	1.4	1.9	9.40
1.00	71 X 71	1.5	1.2	10.20	1.5	1.2	1.5	10.20	1.1	1.2	10.20
2.00	100 X 50	1.4	1.4	10.50	1.4	1.4	1.4	10.50	1.4	2.0	10.50
3.00	122 X 41	1.7	1.1	10.46	1.7	1.1	1.7	10.46	1.1	1.7	10.46
4.00	141 X 35	1.0	1.6	10.34	1.0	1.6	1.5	10.34	1.5	2.7	10.35
5.00	158 X 32	1.2	1.4	10.18	1.2	1.4	1.2	10.18	1.3	2.8	10.18

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	1.2	1.4	3.4	7.48	1.2	1.4	7.48	1.2	1.4	2.3	7.48
.25	1.0	1.6	2.0	8.04	1.0	1.6	8.04	1.0	1.6	1.5	8.04
.33	1.7	1.1	2.2	8.68	1.7	1.1	8.68	1.7	1.1	2.2	8.68
.40	1.5	1.3	1.5	9.01	1.5	1.3	9.01	1.5	1.3	3.9	9.01
.50	1.4	1.4	1.8	9.40	1.4	1.4	9.40	1.4	1.4	1.8	9.40
1.00	1.1	1.2	1.5	10.20	1.1	1.2	10.20	1.1	1.2	4.0	10.20
2.00	1.4	1.1	1.4	10.50	1.4	1.1	10.50	1.4	1.1	2.8	10.50
3.00	1.1	1.3	1.4	10.46	1.1	1.3	10.46	1.1	1.3	5.6	10.46
4.00	1.5	1.5	1.2	10.35	1.5	1.5	10.35	1.5	1.5	4.8	10.35
5.00	1.3	1.1	1.5	10.18	1.3	1.1	10.18	1.3	1.1	2.9	10.18

SIX GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE : 10000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	45 x 224	4.13	22.5	74.7	5.19	112.0	15.0	5.35	5.60
.25	50 x 200	4.19	25.0	66.7	5.62	100.0	16.7	5.78	6.18
.33	58 x 173	4.22	29.0	57.7	6.19	86.5	19.3	6.34	6.93
.40	63 x 158	4.22	31.5	52.7	6.55	79.0	21.0	6.69	7.38
.50	71 x 141	4.19	35.5	47.0	7.00	70.5	23.7	7.13	7.91
1.00	100 x 100	4.06	50.0	33.3	8.17	50.0	33.3	8.26	9.10
2.00	141 x 71	3.86	70.5	23.7	8.80	35.5	47.0	8.82	9.58
3.00	173 x 58	3.70	86.5	19.3	8.79	29.0	57.7	8.77	9.51
4.00	200 x 50	3.55	100.0	16.7	8.61	25.0	66.7	8.57	9.30
5.00	224 x 45	3.42	112.0	15.0	8.34	22.5	74.7	8.29	9.04

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	15.6	5.66	1.3	5.60	2.9	31.8	5.66	1.6	31.8	4.1	5.66
.25	9.9	6.20	1.5	6.18	2.8	21.5	6.20	1.1	21.5	4.2	6.20
.33	1.6	6.93	1.0	6.93	3.2	1.2	6.93	1.2	1.2	3.2	6.93
.40	1.1	7.38	1.1	7.38	1.3	1.1	7.38	1.3	1.1	1.3	7.38
.50	1.6	7.90	1.3	7.90	1.5	1.5	7.90	1.5	1.5	2.0	7.90
1.00	1.1	9.10	1.1	9.10	2.5	1.1	9.10	1.4	1.1	2.5	9.10
2.00	1.3	9.57	1.6	9.58	3.0	1.2	9.58	1.0	1.2	4.4	9.58
3.00	1.0	9.50	3.2	9.51	14.4	1.0	9.51	18.2	1.0	15.6	9.51
4.00	1.5	9.29	8.1	9.31	31.3	1.4	9.31	30.4	1.4	27.1	9.31
5.00	1.3	9.03	11.1	9.06	39.8	1.3	9.06	38.8	1.3	39.8	9.06

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 8000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W RATIO	TGT SHAPE	PATTERN 5 D(1)	PATTERN 5 D(2)	PATTERN 5 COV	PATTERN 6 D(1)	PATTERN 6 D(2)	PATTERN 6 D(3)	PATTERN 6 COV	PATTERN 7 D(1)	PATTERN 7 D(2)	PATTERN 7 COV
.20	45 x 224	1.6	1.5	5.60	1.6	28.0	43.5	5.66	56.1	1.7	5.67
.25	50 x 200	1.1	1.4	6.18	1.1	15.9	41.9	6.20	39.0	1.4	6.21
.33	58 x 173	1.2	1.2	6.93	1.2	1.2	3.2	6.93	3.6	1.8	6.93
.40	63 x 158	1.3	1.1	6.38	1.3	1.1	2.4	6.38	1.2	1.1	7.38
.50	71 x 141	2.0	1.5	7.90	1.5	1.5	2.0	7.90	1.5	1.6	7.90
1.00	100 x 100	1.8	1.1	9.10	1.4	1.1	1.8	9.10	1.8	2.0	9.10
2.00	141 x 71	1.5	1.2	9.58	1.0	1.2	1.5	9.58	1.1	1.5	9.58
3.00	173 x 58	1.2	1.0	9.51	1.1	1.0	1.2	9.51	1.6	10.8	9.51
4.00	200 x 50	1.4	1.4	9.30	1.2	1.4	1.4	9.30	1.4	18.4	9.31
5.00	224 x 45	30.4	1.3	9.04	39.0	1.3	1.4	9.04	1.2	22.9	9.06

L/W RATIO	PATTERN 8 D(1)	PATTERN 8 D(2)	PATTERN 8 D(3)	PATTERN 8 COV	PATTERN 9 D(1)	PATTERN 9 D(2)	PATTERN 9 COV	PATTERN 10 D(1)	PATTERN 10 D(2)	PATTERN 10 D(3)	PATTERN 10 COV
.20	56.2	1.3	57.6	5.67	56.0	1.3	5.65	64.0	1.3	3.1	5.65
.25	39.1	1.4	38.2	6.21	32.7	1.4	6.19	39.1	1.4	4.1	6.19
.33	1.1	1.0	5.4	6.93	1.2	1.0	6.93	1.1	1.0	3.6	6.93
.40	1.2	1.1	1.2	7.38	1.2	1.1	7.38	1.2	1.1	3.4	7.38
.50	1.0	1.2	2.0	7.90	1.0	1.2	7.90	1.0	1.2	3.0	7.90
1.00	1.4	1.1	1.8	9.10	1.4	1.1	9.10	1.4	1.1	3.5	9.10
2.00	1.1	1.5	1.5	9.58	1.1	1.5	9.58	1.1	1.5	4.0	9.58
3.00	1.6	9.0	1.2	9.51	1.6	1.2	9.51	1.6	1.2	2.2	9.51
4.00	1.4	18.8	1.1	9.31	1.4	1.4	9.30	1.4	1.4	41.9	9.30
5.00	1.2	21.7	2.1	9.06	1.2	1.5	9.04	1.2	15.5	41.0	9.05

SIX GUN BATTERY

RANGE TO TARGET : 8000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	63 x 316	3.55	31.5	105.3	3.91	158.0	21.0	4.02	3.98
.25	71 x 283	3.76	35.5	94.3	4.25	141.5	23.7	4.37	4.42
.33	81 x 246	3.95	40.5	82.0	4.69	123.0	27.0	4.83	5.03
.40	89 x 224	4.03	44.5	74.7	4.99	112.0	29.7	5.14	5.46
.50	100 x 200	4.07	50.0	66.7	5.36	100.0	33.3	5.50	5.99
1.00	141 x 141	3.95	70.5	47.0	6.41	70.5	47.0	6.49	7.42
2.00	200 x 100	3.61	100.0	33.3	6.96	50.0	66.7	6.98	8.06
3.00	246 x 81	3.34	123.0	27.0	6.92	40.5	82.0	6.92	7.96
4.00	283 x 71	3.12	141.5	23.7	6.69	35.5	94.3	6.69	7.67
5.00	316 x 63	2.93	158.0	21.0	6.47	31.5	105.3	6.46	7.35

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	30.2	4.17	1.5	3.98	1.8	64.6	4.17	1.3	64.6	2.4	4.17
.25	24.8	4.57	1.7	4.42	1.5	53.5	4.58	1.5	52.1	4.0	4.58
.33	19.4	5.13	1.5	5.03	2.0	41.0	5.13	1.1	41.0	2.0	5.13
.40	15.1	5.52	1.6	5.46	1.6	31.8	5.52	1.2	31.8	2.2	5.52
.50	10.3	6.00	1.5	5.99	2.5	22.2	6.00	1.4	22.2	3.5	6.00
1.00	1.6	7.42	1.6	7.42	2.0	1.5	7.42	1.0	1.5	3.0	7.42
2.00	1.1	8.06	7.2	8.06	25.7	1.1	8.06	26.2	1.1	25.7	8.06
3.00	1.5	7.96	12.5	7.98	44.6	1.4	7.98	44.7	1.4	45.3	7.98
4.00	1.3	7.66	15.9	7.71	56.0	1.2	7.72	56.7	1.2	56.0	7.72
5.00	1.1	7.35	18.9	7.43	65.8	1.2	7.43	66.0	1.1	65.9	7.43

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET : 8000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	63 X 316	1.3	58.2	4.16	1.3	59.2	57.8	4.17	101.0	1.5	4.17
.25	71 X 283	1.5	50.0	4.56	1.5	45.3	69.5	4.58	86.6	1.6	4.59
.33	81 X 246	1.1	1.7	5.03	1.1	34.2	68.7	5.14	69.2	1.9	5.14
.40	89 X 224	1.2	1.5	5.46	1.2	27.3	58.5	5.52	56.1	2.0	5.53
.50	100 X 200	1.8	1.4	5.99	1.4	15.9	42.7	6.00	38.2	2.0	6.01
1.00	141 X 141	1.0	1.5	7.42	1.0	1.5	2.0	7.42	1.5	2.7	7.42
2.00	200 X 100	1.2	1.1	8.06	1.2	1.1	1.4	8.06	1.4	14.2	8.06
3.00	246 X 81	36.8	1.4	7.96	44.7	1.4	1.7	7.96	1.1	25.1	7.98
4.00	283 X 71	53.0	1.2	7.69	62.6	1.2	1.9	7.69	1.1	33.5	7.71
5.00	316 X 63	63.5	1.1	7.41	75.6	1.1	2.2	7.41	1.7	40.0	7.43

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	101.2	1.1	101.0	4.17	99.8	1.1	4.15	129.7	1.1	4.3	4.16
.25	86.7	1.2	84.5	4.59	85.5	1.2	4.56	106.3	1.2	1.9	4.56
.33	68.1	1.4	69.2	5.14	66.8	1.4	5.12	80.6	1.4	1.7	5.12
.40	56.2	1.5	57.6	5.53	53.0	1.5	5.50	64.0	1.5	4.6	5.50
.50	39.1	1.1	34.8	6.01	34.8	1.1	5.99	40.0	1.1	2.7	5.99
1.00	1.0	1.5	2.0	7.42	1.0	1.5	7.42	1.0	1.5	3.0	7.42
2.00	1.4	13.8	1.4	8.06	1.4	1.4	8.06	1.4	1.4	30.9	8.06
3.00	1.1	27.4	1.1	7.98	1.1	1.7	7.96	1.1	20.5	48.7	7.98
4.00	1.1	32.5	2.0	7.71	1.1	1.0	7.67	1.1	25.1	59.1	7.71
5.00	1.7	38.5	1.8	7.43	1.7	1.2	7.35	1.7	32.8	61.7	7.42

SIX GUN BATTERY

RANGE TO TARGET :12000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	32 X 158	2.80	16.0	52.7	3.90	79.0	10.7	3.95	4.25
.25	35 X 141	2.83	17.5	47.0	4.09	70.5	11.7	4.14	4.42
.33	41 X 122	2.85	20.5	40.7	4.31	61.0	13.7	4.35	4.59
.40	45 X 112	2.86	22.5	37.3	4.42	56.0	15.0	4.46	4.68
.50	50 X 100	2.87	25.0	33.3	4.55	50.0	16.7	4.59	4.77
1.00	71 X 71	2.88	35.5	23.7	4.82	35.5	23.7	4.83	4.95
2.00	100 X 50	2.86	50.0	16.7	4.92	25.0	33.3	4.93	5.01
3.00	122 X 41	2.84	61.0	13.7	4.92	20.5	40.7	4.91	5.00
4.00	141 X 35	2.91	70.5	11.7	4.89	17.5	47.0	4.88	4.97
5.00	158 X 32	2.79	79.0	10.7	4.84	16.0	52.7	4.82	4.93

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	1.1	4.25	2.0	4.25	4.4	1.1	4.25	1.1	1.1	6.7	4.25
.25	1.6	4.42	1.9	4.42	4.8	1.5	4.42	1.2	1.5	4.8	4.42
.33	1.4	4.59	1.6	4.59	2.6	1.3	4.59	1.4	1.3	2.6	4.59
.40	1.3	4.68	1.3	4.68	6.1	1.2	4.68	1.6	1.2	6.1	4.68
.50	1.1	4.77	2.0	4.77	4.2	1.1	4.77	1.1	1.1	6.5	4.77
1.00	1.3	4.95	1.7	4.95	4.0	1.2	4.95	1.5	1.2	6.0	4.95
2.00	1.5	5.01	2.0	5.01	3.5	1.4	5.01	1.4	1.4	5.2	5.01
3.00	1.2	5.00	1.8	5.00	3.0	1.1	5.00	1.7	1.1	4.3	5.00
4.00	1.0	4.97	2.1	4.97	2.0	1.6	4.97	1.0	1.6	3.0	4.97
5.00	1.5	4.92	2.0	4.93	1.2	1.4	4.93	1.2	1.4	1.2	4.93

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET :12000 METERS
TARGET SIZE : 5000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	32 X 158	2.0	1.1	4.25	1.1	1.1	2.9	4.25	2.3	3.8	4.25
.25	35 X 141	1.2	1.5	4.42	1.2	1.5	2.2	4.42	2.0	2.9	4.42
.33	41 X 122	1.9	1.3	4.59	1.4	1.3	3.7	4.59	2.2	2.1	4.59
.40	45 X 112	2.1	1.2	4.68	1.6	1.2	2.9	4.68	2.7	3.3	4.68
.50	50 X 100	1.4	1.1	4.77	1.1	1.1	2.0	4.77	1.8	2.5	4.77
1.00	71 X 71	1.5	1.2	4.95	1.5	1.2	2.0	4.95	2.1	3.2	4.95
2.00	100 X 50	2.5	1.4	5.01	1.4	1.4	1.4	5.01	1.8	2.8	5.01
3.00	122 X 41	3.0	1.1	5.00	1.7	1.1	3.0	5.00	1.4	3.4	5.00
4.00	141 X 35	1.5	1.6	4.97	1.0	1.6	3.0	4.97	2.0	2.7	4.97
5.00	158 X 32	1.7	1.4	4.93	1.2	1.4	2.3	4.93	1.8	2.8	4.93

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	1.2	1.4	3.4	4.25	1.7	1.4	4.25	1.2	1.4	5.0	4.25
.25	1.0	1.6	3.0	4.42	1.0	1.6	4.42	1.0	1.6	6.9	4.42
.33	1.7	1.1	2.2	4.59	2.2	1.1	4.59	1.7	1.1	2.2	4.59
.40	1.5	1.3	3.9	4.68	2.0	1.3	4.68	1.5	1.3	5.8	4.68
.50	1.4	1.4	2.5	4.77	1.4	1.4	4.77	1.4	1.4	5.2	4.77
1.00	1.1	1.2	2.7	4.95	1.5	1.2	4.95	1.1	1.2	6.0	4.95
2.00	1.4	1.1	2.8	5.01	1.8	1.1	5.01	1.4	1.1	6.5	5.01
3.00	1.1	1.3	1.9	5.00	1.1	1.3	5.00	1.1	1.3	5.6	5.00
4.00	1.5	1.5	2.2	4.97	1.5	1.5	4.97	1.5	1.5	4.8	4.97
5.00	1.3	1.1	2.0	4.93	1.3	1.1	4.93	1.3	1.1	4.4	4.93

SIX GUN BATTERY

RANGE TO TARGET :12000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	45 X 224	2.65	22.5	74.7	3.20	112.0	15.0	3.25	3.58
.25	50 X 200	2.71	25.0	66.7	3.43	100.0	16.7	3.48	3.81
.33	58 X 173	2.76	29.0	57.7	3.70	86.5	19.3	3.76	4.08
.40	63 X 158	2.79	31.5	52.7	3.86	79.0	21.0	3.92	4.23
.50	71 X 141	2.81	35.5	47.0	4.05	70.5	23.7	4.10	4.39
1.00	100 X 100	2.83	50.0	33.3	4.46	50.0	33.3	4.49	4.70
2.00	141 X 71	2.80	70.5	23.7	4.63	35.5	47.0	4.64	4.81
3.00	173 X 58	2.75	86.5	19.3	4.61	29.0	57.7	4.61	4.78
4.00	200 X 50	2.70	100.0	16.7	4.55	25.0	66.7	4.53	4.72
5.00	224 X 45	2.65	112.0	15.0	4.46	22.5	74.7	4.43	4.65

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	1.5	3.58	2.4	3.57	2.1	1.5	3.58	1.6	1.5	2.9	3.58
.25	1.4	3.81	1.5	3.81	2.8	1.4	3.81	1.1	1.4	4.2	3.81
.33	1.2	4.08	1.0	4.08	1.2	1.2	4.08	1.2	1.2	1.6	4.08
.40	1.1	4.23	1.1	4.23	2.4	1.1	4.23	1.3	1.1	2.4	4.23
.50	1.6	4.38	1.3	4.39	1.5	1.5	4.39	1.5	1.5	1.5	4.39
1.00	1.1	4.70	1.1	4.70	5.2	1.1	4.70	1.4	1.1	8.0	4.70
2.00	1.3	4.80	2.1	4.81	2.0	1.2	4.81	1.0	1.2	3.0	4.81
3.00	1.0	4.78	2.2	4.78	5.4	1.0	4.78	1.1	1.0	8.4	4.78
4.00	1.5	4.72	2.5	4.72	2.7	1.4	4.72	1.2	1.4	2.7	4.72
5.00	1.3	4.65	2.8	4.65	7.0	1.3	4.65	1.4	1.3	10.8	4.65

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET :12000 METERS
TARGET SIZE :10000 SQUARE METERS

L/W RATIO	TGT SHAPE	PATTERN 5 D(1)	PATTERN 5 D(2)	PATTERN 5 COV	PATTERN 6 D(1)	PATTERN 6 D(2)	PATTERN 6 D(3)	PATTERN 6 COV	PATTERN 7 D(1)	PATTERN 7 D(2)	PATTERN 7 COV
.20	45 x 224	2.1	1.5	3.57	1.6	1.5	9.4	3.57	3.1	1.7	3.58
.25	50 x 200	1.1	1.4	3.81	1.1	1.4	2.8	3.81	2.7	2.5	3.81
.33	58 x 173	2.2	1.2	4.08	1.2	1.2	4.9	4.08	1.2	1.3	4.08
.40	63 x 158	2.4	1.1	4.23	1.3	1.1	3.5	4.23	1.7	2.0	4.23
.50	71 x 141	2.0	1.5	4.38	1.5	1.5	4.0	4.38	1.5	2.2	4.39
1.00	100 x 100	2.5	1.1	4.70	1.4	1.1	2.5	4.70	1.4	1.1	4.70
2.00	141 x 71	2.0	1.2	4.80	1.0	1.2	3.0	4.80	1.5	2.7	4.81
3.00	173 x 58	1.8	1.0	4.78	1.1	1.0	2.4	4.78	2.0	3.0	4.78
4.00	200 x 50	2.0	1.4	4.72	1.2	1.4	2.7	4.72	1.8	3.5	4.72
5.00	224 x 45	3.1	1.3	4.65	1.4	1.3	1.6	4.65	1.6	5.8	4.65

L/W RATIO	PATTERN 8 D(1)	PATTERN 8 D(2)	PATTERN 8 D(3)	PATTERN 8 COV	PATTERN 9 D(1)	PATTERN 9 D(2)	PATTERN 9 COV	PATTERN 10 D(1)	PATTERN 10 D(2)	PATTERN 10 D(3)	PATTERN 10 COV
.20	1.4	1.3	3.1	3.58	2.2	1.3	3.57	1.4	1.3	7.0	3.57
.25	1.2	1.4	4.1	3.81	1.2	1.4	3.81	1.2	1.4	4.1	3.81
.33	1.1	1.0	1.8	4.08	2.4	1.0	4.08	1.1	1.0	8.4	4.08
.40	1.2	1.1	1.7	4.23	2.3	1.1	4.23	1.2	1.1	1.7	4.23
.50	1.0	1.2	2.0	4.39	1.0	1.2	4.39	1.0	1.2	3.0	4.39
1.00	1.4	1.1	1.4	4.70	1.8	1.1	4.70	1.4	1.1	8.0	4.70
2.00	1.1	1.5	2.0	4.81	1.1	1.5	4.81	1.1	1.5	4.0	4.81
3.00	1.6	1.2	2.2	4.78	1.6	1.2	4.78	1.6	1.2	7.5	4.78
4.00	1.4	1.4	2.0	4.72	1.4	1.4	4.72	1.4	1.4	4.2	4.72
5.00	1.2	1.5	2.9	4.65	1.2	1.5	4.65	1.2	1.5	9.4	4.65

SIX GUN BATTERY

RANGE TO TARGET :12000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	LAZY W	BCS HORIZONTAL			BCS VERTICAL			ZERO
RATIO	SHAPE	COV	D(1)	D(2)	COV	D(1)	D(2)	COV	COV
.20	63 x 316	2.35	31.5	105.3	2.50	158.0	21.0	2.56	2.75
.25	71 x 283	2.46	35.5	94.3	2.70	141.5	23.7	2.76	3.01
.33	81 x 246	2.57	40.5	82.0	2.97	123.0	27.0	3.02	3.33
.40	89 x 224	2.62	44.5	74.7	3.14	112.0	29.7	3.19	3.53
.50	100 x 200	2.67	50.0	66.7	3.35	100.0	33.3	3.40	3.76
1.00	141 x 141	2.73	70.5	47.0	3.88	70.5	47.0	3.92	4.26
2.00	200 x 100	2.67	100.0	33.3	4.11	50.0	66.7	4.11	4.43
3.00	246 x 81	2.58	123.0	27.0	4.07	40.5	82.0	4.06	4.39
4.00	283 x 71	2.50	141.5	23.7	3.96	35.5	94.3	3.94	4.29
5.00	316 x 63	2.42	158.0	21.0	3.84	31.5	105.3	3.82	4.18

L/W	PATTERN 1		PATTERN 2		PATTERN 3			PATTERN 4			
RATIO	D	COV	D	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	18.2	2.78	1.5	2.75	1.3	39.4	2.78	1.3	38.5	8.1	2.78
.25	14.6	3.02	1.7	3.01	4.0	31.0	3.02	1.5	29.6	9.2	3.02
.33	8.1	3.33	2.0	3.33	1.1	17.0	3.33	1.1	17.0	1.1	3.33
.40	1.5	3.53	2.0	3.53	2.2	1.5	3.53	1.2	1.5	3.1	3.53
.50	1.4	3.76	1.5	3.76	3.5	1.4	3.76	1.4	1.4	5.2	3.76
1.00	1.6	4.25	2.1	4.26	3.0	1.5	4.26	1.0	1.5	4.4	4.26
2.00	1.1	4.43	2.5	4.43	6.2	1.1	4.43	1.2	1.1	9.6	4.43
3.00	1.5	4.38	3.0	4.39	11.9	1.4	4.38	1.5	1.4	11.9	4.38
4.00	1.3	4.28	7.6	4.29	30.4	1.2	4.29	31.1	1.2	28.5	4.29
5.00	1.1	4.18	11.4	4.18	44.9	1.5	4.18	44.1	1.1	42.8	4.18

SIX GUN BATTERY (CONTINUED)

RANGE TO TARGET :12000 METERS
TARGET SIZE :20000 SQUARE METERS

L/W	TGT	PATTERN 5			PATTERN 6				PATTERN 7		
RATIO	SHAPE	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV
.20	63 x 316	1.3	1.2	2.75	1.3	32.8	60.6	2.78	64.9	1.5	2.78
.25	71 x 283	2.0	1.0	3.01	1.5	24.5	52.3	3.02	50.2	2.2	3.02
.33	81 x 246	2.0	1.7	3.33	1.1	12.0	26.4	3.33	30.0	2.6	3.33
.40	89 x 224	2.2	1.5	3.53	1.2	1.5	11.1	3.53	3.1	2.0	3.53
.50	100 x 200	2.5	1.4	3.75	1.4	1.4	2.5	3.76	2.7	3.1	3.76
1.00	141 x 141	2.0	1.5	4.25	1.0	1.5	1.0	4.26	2.0	2.7	4.26
2.00	200 x 100	1.4	1.1	4.43	1.2	1.1	2.0	4.43	1.8	5.2	4.43
3.00	246 x 81	2.4	1.4	4.38	1.5	1.4	1.5	4.38	2.0	6.4	4.38
4.00	283 x 71	2.8	1.2	4.28	1.7	1.2	4.0	4.28	1.5	16.7	4.29
5.00	316 x 63	3.2	1.1	4.18	2.0	1.1	3.2	4.18	1.7	25.3	4.18

L/W	PATTERN 8				PATTERN 9			PATTERN 10			
RATIO	D(1)	D(2)	D(3)	COV	D(1)	D(2)	COV	D(1)	D(2)	D(3)	COV
.20	66.0	1.1	64.7	2.78	62.5	1.1	2.77	76.6	1.1	6.5	2.77
.25	51.4	1.2	49.2	3.02	48.1	1.2	3.02	56.7	1.2	5.8	3.02
.33	28.9	1.4	29.1	3.33	2.4	1.4	3.33	1.5	1.4	7.6	3.33
.40	1.4	1.5	3.1	3.53	2.2	1.5	3.53	1.4	1.5	7.0	3.53
.50	1.2	1.1	4.1	3.76	1.4	1.1	3.76	1.2	1.1	4.1	3.76
1.00	1.0	1.5	3.0	4.26	1.0	1.5	4.26	1.0	1.5	4.4	4.26
2.00	1.4	1.4	2.5	4.43	1.4	1.4	4.43	1.4	1.4	8.0	4.43
3.00	1.1	1.7	2.8	4.38	1.4	1.7	4.38	1.1	1.7	16.3	4.38
4.00	1.1	19.6	2.0	4.29	1.1	1.0	4.29	1.1	1.0	40.7	4.29
5.00	1.7	24.2	1.3	4.18	2.2	1.2	4.18	1.7	1.2	50.3	4.18

APPENDIX C

Computer Program

This appendix contains a FORTRAN program listing for the computer model SNOW'S QUICKIE as modified for use in this thesis.

```
C INPUT DATA FOR THE FOLLOWING CARD SETS MAY APPEAR ANYWHERE IN THE      A  29
C SPECIFIED COLUMNS IF A DECIMAL POINT IS PUNCHED: 2 6 7 8 9 10 11 12
C                                                  13 14
C NOTE:   IF A DECIMAL POINT IS NOT PUNCHED THE DATA MUST BE LOCATED IN
C         THE SPECIFIED COLUMNS ACCORDING TO THE CORRESPONDING FORMAT
C         STATEMENT.
C                                                                        A  31
C                                                                        A  32
C  CARD                NAME OF                                           A  33
C  SET     COLUMNS   VARIABLES                DESCRIPTION                A  34
C                                                                        A  35
C   1     *   1-5   * IFLAG      * FLAG TO INDICATE TYPE OF ROUND FOR WHICH  A  36
C         *         *            * DATA IS INPUT:  USE 0 FOR HE          A  37
C         *         *            *                   1 FOR ICM           A  38
C   1     *   6-10  * IFLAG2     * FLAG TO TELL THE PROGRAM WHAT TO DO AFTER A  39
C         *         *            * PROCESSING THE CURRENT SET OF INPUT DATA  A  40
C         *         *            * = 0 - READ A NEW SET OF INPUT DATA    A  41
C         *         *            * = 12 - STOP                           A  42
C   1     *  11-15  * NCASLEV    * THE TOTAL NUMBER OF CASUALTY LEVELS FOR
C         *         *            * WHICH EFFECTIVENESS DATA ARE TO BE COMPUT-
C         *         *            * ED.  IF NCASLEV IS SET = 0, NO INTERPRE-
C         *         *            * TATION IS DONE FOR THE EXACT NUMBER OF  A  46
C         *         *            * ROUNDS: **AND** CARD SET 2 MUST NOT BE  A  47
C         *         *            * ENTERED                               A  48
C                                                                        A  49
C*********************************************************************** A  50
C                                                                        A  51
C   2     *  1-10   * CASIN(1)   * THE FIRST CASUALTY LEVEL(OR PERCENT OF THE A  52
C         *         *            * TARGET TO BE DEFEATED).  THE PROGRAM WILL  A  53
C         *         *            * COMPUTE THE NUMBER OF ROUNDS REQUIRED TO   A  54
C         *         *            * PRODUCE THIS CASUALTY LEVEL--IF IT CAN BE  A  55
C         *         *            * ACHIEVED WITH THE SPECIFIED NUMBER OF      A  56
C         *         *            * VOLLEYS.                              A  57
```

```
*DECK QUICKIE
      PROGRAM QUICKIE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION ITYPE(10)
      DIMENSION NN(20), A(50), B(50), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,N3,CNN,TTT,CN3,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
      COMMON /BLOCK2/ NCASLEV,CASIN(8)
      REAL MPIR,MPID,LL,LD
      DATA (NN(I),I=1,20)/1,2,3,4,5,6,7,8,9,10,12,14,16,18,20,25,30,35,4
     10,50/
      PI=3.1415926E
      PI2=PI*2.
      SQR2=SQRT(2.)
C
C**********************************************************************
C
C                          INPUT GUIDE
C
C INPUT DATA FOR THE FOLLOWING CARD SETS MUST BE RIGHT JUSTIFIED IN
C THE SPECIFIED COLUMNS: 1 3 4 5
C
```

```
C    2     * 11-20 * CASIN(2)  * THE SECOND CASUALTY LEVEL                         A  58
C          *   .   *     .     *                                                   A  59
C          *   .   *     .     * REPEAT UNTIL ALL NCASLEV HAVE BEEN                A  60
C          *   .   *     .     * SPECIFIED.  A MAXIMUN OF 8 CASUALTY LEVELS        A  61
C          *   .   *     .     * MAY BE SPECIFIED.                                 A  62
C          *   .   *     .     *                                                   A  63
C          *   .   * CASIN(NCASLEV)                                                A  64
C                                                                                  A  65
C*******************************************************************************    A  66
C                                                                                  A  67
C    3     *  1-5  * NJM       * THE NUMBER TO PLACE ON THE FIRST SET OF           A  68
C          *       *           * DATA WHEN IT IS PRINTED.  THIS NUMBER IS          A  69
C          *       *           * INCREMENTED FOR EACH SET OF DATA PRINTED          A  70
C          *       *           * FOR THIS SET OF INPUT DATA                        A  71
C    3     *  6-10 * NPOST     * THE TOTAL NUMBER OF POSTURE SEQUENCES FOR
C          *       *     .     * WHICH EFFECTIVENESS DATA ARE TO BE
C          *       *           * COMPUTED.  IF NPOST = 0, NO POSTURE
C          *       *           * SEQUENCING IS DONE **AND** CARD SET NUMBER
C          *       *           * 5 MUST NOT BE ENTERED.
C    3     * 11-15 * N         * THE NUMBER OF ROUNDS IN EACH VOLLEY OR            A  74
C          *       *           * THE NUMBER OF AIM POINTS OR PIECES                A  75
C          *       *           * (HOWITIZERS) IN EACH VOLLEY.                      A  76
C    3     * 16-20 * NVS       * THE TOTAL NUMBER OF DISTINCT VOLLEY SIZES
C          *       *           * FOR WHICH EFFECTIVENESS DATA ARE TO BE
C          *       *           * COMPUTED
C    3     * 21-25 * NTS       * THE TOTAL NUMBER OF TARGET SIZES FOR
C          *       *           * WHICH EFFECTIVENESS DATA ARE TO BE
C          *       *           * COMPUTED
C    3     * 26-30 * NRG       * THE TOTAL NUMBER OF RANGES FOR WHICH
C          *       *           * EFFECTIVENESS DATA ARE TO BE COMPUTED
C    3     * 31-35 * NTLE      * THE TOTAL NUMBER OF TARGET LOCATION ERRORS
```

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C        *     *          * FOR WHICH EFFECTIVENESS DATA ARE TO BE
C        *     *          * COMPUTED
C                                                                        A  85
C THE PROGRAM WILL OUTPUT NTS*NRG*NTLE DIFFERENT SETS OF EFFECTIVENESS   A  86
C DATA.  THE FIRST SET WILL CONSIST OF EFFECTIVENESS DATA FOR ALL THE    A  87
C VOLLEY SIZES SPECIFIED AND FOR NRG(1),NTLE(1), AND NTS(1): THE SECOND  A  88
C SET WILL BE FOR ALL THE VOLLEY SIZES SPECIFIED AND FOR NRG(1),         A  89
C NTLE(1), AND NTS(2): ETC.                                              A  90
C                                                                        A  91
C***********************************************************************  A  92
C                                                                        A  93
C   +    *  1-5  * NN(1)    * THE FIRST VOLLEY SIZE FOR WHICH EFFECTIVE- A  94
C        *       *          * NESS DATA ARE TO BE COMPUTED               A  95
C   +    *  6-10 * NN(2)    * THE SECOND VOLLEY SIZE FOR WHICH EFFECTIVE A  96
C        *       *          * NESS DATA ARE TO BE COMPUTED               A  97
C        *   .   *   .      *                                            A  98
C        *       *          * CONTINUE UNTIL ALL NVS HAVE BEEN SPECIFIED A  99
C        *   .   *   .      * A MAXIMUN OF 50 VOLLEY SIZES MAY BE        A 100
C        *   .   *   .      * SPECIFIED.  UP TO 10 VALUES MAY BE ENTERED A 101
C        *   .   *   .      * PER CARD                                   A 102
C        *   .   *   .      *                                            A 103
C        *   .   * NN(NVS)  *                                            A 104
C                                                                        A 105
C***********************************************************************  A 106
C                                                                        A 107
C   5    *  1-5  * IPOST(1) * THE NUMBER ASSOCIATED WITH THE 1ST POSTURE A 108
C        *       *          * SEQUENCE FOR WHICH THE NUMBER OF ROUNDS    A 109
C        *       *          * REQUIRED TO PRODUCE EACH SPECIFIED         A 110
C        *       *          * CASUALTY LEVEL IS TO BE COMPUTED.          A 111
C   5    *  6-10 * IPOST(2) * THE NUMBER ASSOCIATED WITH THE 2ND POSTURE A 112
C        *       *          * SEQUENCE FOR WHICH EFFECTIVENESS DATA ARE  A 113
C        *       *          * TO BE COMPUTED                             A 114
C        *   .   *    .     *                                            A 115
```

```
C           *   .   *       .       * CONTINUE UNTIL ALL NPOST POSTURE SEQUENCES   A 116
C           *   .   *       .       * HAVE BEEN SPECIFIED.  A MAXIMUN OF 10 PRE-   A 117
C           *   .   *       .       * DETERMINED POSTURE SEQUENCES MAY BE          A 118
C           *   .   *       .       * SPECIFIED.  THE PRE-DETERMINED POSTURE       A 119
C           *   .   *       .       * SEQUENCES ARE DEFINED IN SUBROUTINE POST     A 120
C           *   .   *       .       *                                              A 121
C           *   .   * IPOST(NPOST)                                                 A 122
C                                                                                  A 123
C********************************************************************************   A 124
C                                                                                  A 125
C     6     *  1-10 * A(1)          * THE AIM POINT IN RANGE FOR THE 1ST ROUND     A 126
C     6     * 11-20 * B(1)          * THE AIM POINT IN DEFL FOR THE 1ST ROUND      A 127
C           *   .   *   .           *                                              A 128
C           *   .   *   .           * REPEAT UNTIL THE AIM POINTS FOR ALL N        A 129
C           *   .   *   .           * ROUNDS HAVE BEEN ENTERED.  A MAZIMUN OF 54   A 130
C           *   .   *   .           * AIM POINTS MAY BE ENTERED.  HOWEVER, ONLY    A 131
C           *   .   *   .           * 6 VALUES MAY BE ENTERED PER CARD: I.E., 3    A 132
C           *   .   *   .           * AIM POINTS PER CARD                          A 133
C           *   .   *   .           *                                              A 134
C           *   .   * A(N)          *                                              A 135
C           *   .   * B(N)          *                                              A 136
C                                                                                  A 137
C********************************************************************************   A 138
C                                                                                  A 139
C     7     *  1-10 * U1            * NUMBER OF INTERGRATION STEPS IN RANGE        A 140
C     7     * 11-20 * U2            * NUMBER OF INTERGRATION STEPS IN DEFLECTION   A 141
C     7     * 21-30 * SU1           * VOLLEY AIM POINT IN RANGE                    A 142
C     7     * 31-40 * SU2           * VOLLEY AIM POINT IN DEFLECTION               A 143
C                                                                                  A 144
C********************************************************************************   A 145
C                                                                                  A 146
```

```
C    8     *  1-10 * REL        * IN FLIGHT PROJECTILE RELIABILITY                 A 147
C    8     * 11-20 * DS         * DAMAGE FUNCTION PARAMETER FOR STANDING           A 148
C          *       *            * PERSONNEL - FOR ICM USE 1., FOR HE USE .2
C    8     * 21-30 * DP         * SAME BUT FOR PRONE PERSONNEL                     A 150
C    8     * 31-40 * DC         * SAME BUT FOR PERSONNEL CROUCHING IN              A 151
C          *       *            * FOXHOLES                                         A 152
C                                                                                  A 153
C***************************************************************************       A 154
C                                                                                  A 155
C    9     *  1-10 * AA3(1)     * TARGET LENGTH IN RANGE FOR 1ST TARGET: OR        A 156
C          *       *            * THE RADIUS OF THE TARGET,  THE PROGRAM           A 157
C          *       *            * WILL CONSIDER THE ENTRY IN AA3 AS THE            A 158
C          *       *            * RADIUS OF THE TARGET IF AA4 IS ENTERED AS        A 159
C          *       *            * 0.0                                              A 160
C    9     * 11-20 * AA4(1)     * TARGET WIDTH IN DEFL FOR 1ST TARGET              A 161
C          *   .   *   .        *                                                  A 162
C          *   .   *   .        * REPEAT FOR EACH OF THE NTS TARGETS.  A           A 163
C          *   .   *   .        * MAXIMUN OF 10 TARGETS MAY BE SPECIFIED. UP       A 164
C          *   .   *   .        * TO 8 VALUES MAY BE ENTERED PER CARD ( I.E.
C          *   .   *   .        * 4 TARGETS MAY BE ENTEDED PER CARD.)
C          *   .   * AA3(NTS)   *                                                  A 167
C          *   .   * AA4(NTS)   *                                                  A 168
C                                                                                  A 169
C***************************************************************************       A 170
C                                                                                  A 171
C   10     *  1-10 * TLE(1)     * TARGET LOCATION ERROR IN CIRCULAR PROBABLE       A 172
C          *       *            * ERRORS(CPE) FOR THE FIRST SET OF DATA            A 173
C   10     * 11-20 * TLE(2)     * SAME FOR THE SECOND SET OF DATA                  A 174
C          *   .   *   .        *                                                  A 175
C          *   .   *   .        * REPEAT FOR EACH NTLE UNTIL ALL THE TLE           A 176
C          *   .   *   .        * HAVE BEEN SPECIFIED  A MAXIMUN OF 10             A 177
C          *   .   *   .        * TLE MAY BE SPECIFIED.  UP TO 8 VALUES MAY        A 178
C          *   .   *   .        * BE ENTERED PER CARD                              A 179
```

```
C         *    .    *    .    *
C         *    .    * TLI(NTLE)*
C
C***********************************************************************
C
C CARD SETS 11 12 & 13 ARE REPEATED 1 CARD FOR EACH RANGE.  I.E. THERE
C MUST BE NRG CARDS IN EACH SET.  THE FIRST CARD GIVES THE DATA FOR THE
C FIRST RANGE FOR WHICH EFFECTIVENESS DATA ARE TO BE COMPUTED: THE
C  SECOND CARD GIVES THE DATA FOR THE SECOND RANGE FOR WHICH EFFECTIVE-
C NESS DATA ARE TO BE COMPUTED: ETC. DATA FOR UP TO 10 RANGES MAY BE
C ENTERED.
C
C THE UNITS FOR THE LETHAL AREAS (CARD SET 11) ARE SQUARE METERS.
C
C    11    *  1-10 * AALS      * LETHAL AREA FOR STANDING PERSONNEL
C    11    * 11-20 * AALP      * LETHAL AREA FOR PRONE PERSONNEL
C    11    * 21-30 * AALC      * LETHAL AREA FOR PERSONNEL CROUCHING IN
C          *       *           * FOXHOLES
C    11    * 31-40 * RRATS     * RATE OF DEFLECTION TO RANGE FOR DAMAGE
C          *       *           * FUNCTION FOR STANDING PERSONNEL: FOR ICM
C          *       *           * USE 1.0 AND FOR HE USE 2.0
C    11    * 41-50 * RRATP     * SAME FOR PRONE PERSONNEL
C    11    * 51-60 * RRATC     * SAME FOR PERSONNEL CROUCHING IN FOSHOLES
C
C***********************************************************************
C
C    12    *   1   * DTYPE     * CODE TO IDENTIFY THE UNITS OF THE DELIVERY
C          *       *           * ACCURACY DATA ON THIS CARD.
C          *       *           *       S - UNITS ARE STANDARD DEVIATIONS
C          *       *           *       P - UNITS ARE PROBABLE ERRORS
C          *       *           *       C - UNITS ARE CPE - IN THIS CASE THE
```

```
C         *       *          *           CPE PRECISSION ERROR IS ENTERED     A 211
C         *       *          *           IN PER AND 0.0 IS ENTERED IN PED:   A 212
C         *       *          *           THE CPE MPI ERROR IS ENTERED IN     A 213
C         *       *          *           MPIR, AND 0.0 IS ENTERED IN MPID
C   12    * 11-20 * PER      * PRECISSION ERROR IN RANGE                     A 215
C   12    * 21-30 * PED      * PRECISSION ERROR IN DEFLECTION                A 216
C   12    * 31-40 * MPIR     * MPI ERROR (AMING ERROR) IN RANGE              A 217
C   12    * 41-50 * MPID     * MPI ERROR (AMING ERROR) IN DEFLECTION         A 218
C                                                                            A 219
C*************************************************************************** A 220
C                                                                            A 221
C THIS CARD SET IS ENTERED FOR ICM'S ONLY.  UNITS ARE METERS.
C
C ENTER THE PATTERN RADIUS FOR THE BOMBLETS
C                                                                            A 228
C   13    *  1-10 * EET1     * OUTER PATTERN RADIUS IN RANGE                 A 229
C   13    * 11-20 * EET2     * OUTER PATTERN RADIUS IN DEFLECTION
C   13    * 21-30 * WW1      * INNER PATTERN RADIUS IN RANGE                 A 231
C   13    * 31-40 * WW2      * INNER PATTERN RADIUS IN DEFLECTION            A 232
C
C***************************************************************************
C
C THIS CARD SET IS ENTERED FOR ICM'S ONLY.
C
C   14    *  1-10 * CN3      * NUMBER OF SUBMUNITIONS IN THE PROJECTILE
C   14    * 11-20 * RELSUB   * SUBMUNITION RELIABILITY
C                                                                            A 240
C*************************************************************************** A 241
C
C
C
C
C FOR EVALUATION OF PATTERNS SEE COMMENTS FOLLOWING LINE A516
```

```
C
C
C
C
C*************************************************************************
C
C
110   READ (5,530) IFLAG,IFLAG2,NCASLEV
      IF (NCASLEV.NE.0) GO TO 120
      CASIN(1)=0.0
      GO TO 130
120   READ (5,510) (CASIN(I),I=1,NCASLEV)
130   READ (5,530) NUM,NPOST,N,NVS,NTS,NRG,NTLE
      READ (5,530) (NN(I),I=1,NVS)
      DO 140 I=1,NVS
140   CNN(I)=NN(I)
      IF (NPOST .NE. 0) GO TO 150
      IPOST(1) = 0
      GO TO 160
150   READ (5,530) (IPOST(I),I=1,NPOST)
160   READ (5,520) (A(I),B(I),I=1,N)
170   READ (5,510) U1,U2,SU1,SU2
180   READ (5,510) REL,DS,DP,DC
190   READ (5,510) (AA3(I),AA4(I),I=1,NTS)
200   READ (5,510) (TTLE(I),I=1,NTLE)
210   READ (5,520) (AALS(I),RRATS(I),I=1,NRG)
220   READ (5,600) (DTYPE(I),SS1(I),SS2(I),TT1(I),TT2(I),I=1,NRG)
C
C     *  CHECK TO SEE IF INPUT DATA IS FOR ICM OR HE
C
      IF (IFLAG.EQ.1) GO TO 240
```

```
C     *  INPUT IS FOR HE.  SET THE ICM VALUES (CARD SET 13) EQUAL TO 0.0
      DO 230 I=1,NRG
      EET1(I)=0
      EET2(I)=0.
      WW1(I)=0.
230   WW2(I)=0.
      CNB=0.
      RELSUB=0.
      GO TO 250
240   CONTINUE
C     *  INPUT IS FOR ICM - READ THE REST OF DATA FOR THIS SET
      READ (5,[illegible]) (EET1(I),EET2(I),WW1(I),WW2(I),I=1,NRG)
      READ (5,[illegible]) CNB,RELSUB
      NB=CNB
250   WRITE (6,[illegible])
C
C     *  RANGE LOOP STARTS HERE - THE HIERARCHY IS RANGE, TLE, AND NTS
C     *  EACH SET OF COMPUTIONS IS CONTROL BY A DO LOOP WITH NTS BEING
C     *  THE INNER LOOP AND NRG THE OUTER LOOP
C
      DO 270 IS=1,NRG
C
C     *  SET BOMBLET PATTERN FOR THIS CASE
C
      ET1=EET1(IS)
      ET2=EET2(IS)
      W1=WW1(IS)
      W2=WW2(IS)
C
C     *  SET UP DELEVERY ACCURACY DATA FOR THIS CASE, ALL UNITS ARE
C     *  CONVERTED TO STANDARD DEVIATIONS
C
      IF (DTYPE(IS).EQ.1HS) GO TO 270
```

```
      IF (DTYPE(I3).EQ.1HP) GO TO 260                                   A 298
C                                                                       A 299
C     *  DELEVERY ACCURCY DATA IS INPUT IN UNITS OF CPE                 A 300
C                                                                       A 301
      IPT = 1
      PER=.8493*SS1(I3)                                                 A 302
      PED=PER                                                           A 303
      MPIR=.8493*TT1(I3)                                                A 304
      MPID=MPIR                                                         A 305
      GO TO 280                                                         A 306
260   CONTINUE                                                          A 307
C                                                                       A 308
C     *  DELIVERY ACCURACY DATA IS INPUT IN UNITS OF PROBABLE ERRORS    A 309
C                                                                       A 310
      IPT = 2
      PER=1.4826*SS1(I3)                                                A 311
      PED=1.4826*SS2(I3)                                                A 312
      MPIR=1.4826*TT1(I3)                                               A 313
      MPID=1.4826*TT2(I3)                                               A 314
      GO TO 280                                                         A 315
270   CONTINUE                                                          A 316
C                                                                       A 317
C     * DELEVERY ACCURCY DATA IS INPUT IN UNITS OF STANDARD DEVIATIONS  A 318
C                                                                       A 319
      IPT = 3
      PER=SS1(I3)                                                       A 320
      PED=SS2(I3)                                                       A 321
      MPIR=TT1(I3)                                                      A 322
      MPID=TT2(I3)                                                      A 323
280   CONTINUE                                                          A 324
      S1=PER                                                            A 325
```

```
      S2=PED                                                              A 326
C                                                                         A 327
C     *  SET LETHAL AREA DATA FOR THIS CASE                               A 328
C                                                                         A 329
      ALS=AALS(I3)                                                        A 330
C                                                                         A 333
C     *  SET RATIO DATA FOR THIS CASE                                     A 334
C                                                                         A 335
      RATS=RRATS(I3)                                                      A 336
C                                                                         A 339
C     * TLE LOOP STARTS HERE                                              A 340
C                                                                         A 341
      DO 470 I2=1,NTLE                                                    A 342
      TLE=TTLE(I2)                                                        A 343
C     *  COMBINE THE MPI ERROR WITH THE TLE TO DETERMINE THE TOTAL BIAS   A 344
C     *  ERROR                                                            A 345
      T1=SQRT(MPIR**2+(.8493*TLE)**2)                                     A 346
      T2=SQRT(MPID**2+(.8493*TLE)**2)                                     A 347
C                                                                         A 348
C     *  TARGET SIZE LOOP STARTS HERE                                     A 349
C                                                                         A 350
      DO 470 I1=1,NTS                                                     A 351
C                                                                         A 352
C     *  SET THE TARGET SIZE FOR THIS CASE                                A 353
C     *        A3 = LENGTH OF TARGET IN RANGE                             A 354
C     *        A4 = WIDTH OF TARGET IN DEFLECTION                         A 355
C                                                                         A 356
      A3=AA3(I1)                                                          A 357
      A4=AA4(I1)                                                          A 358
C                                                                         A 359
C     *  WRITE THE INPUT DATA FOR THIS CASE                               A 360
C                                                                         A 361
      WRITE (6,540) NUM,IFLAG,NPOST,N,NVS,NTS,NRG,NTLE                    A 362
```

```
      IF (A  .EQ. 0.0) GO TO 282
      WRITE (6,550) U1,U2,SU1,SU2,REL,DS,DP,DC,A3,A4                    A 363
      GO TO 284
282   WRITE (6,550) U1,U2,SU1,SU2,REL,DS,DP,DC,A3
284   CONTINUE
      IF (IPT .EQ. 1) WRITE (6,551)
      IF (IPT .EQ. 2) WRITE (6,552)
      IF (IPT .EQ. 3) WRITE (6,553)
      WRITE (6,560) SS1(I3),SS2(I3),TT1(I3),TT2(I3),TLF,ALS,RATS        A 364
      WRITE (6,580) (A(I),I=1,N)                                        A 367
      WRITE (6,590) (B(I),I=1,N)                                        A 368
C                                                                       A 369
C     *  RAT IS THE RATIO OF R2/R1, WHICH CHARACTERIZES THE ECCENTRICITY A 370
C     *  OF THE DAMAGE FUNCTION, WHICH IS AN ELLIPSE WITH E = SQRT(1 -   A 371
C     *  R1*R1/R2*R2).  AL(LETHAL AREA) = PI*R1*R2.  R1 AND R2 ARE       A 372
C     *  THE MEAN SQUARE RADIAL DAMAGE DISTANCES ALONG THE X AND Y AXES, A 373
C    .*  RESPECTIVELY.                                                  A 374
C                                                                       A 375
      SR1=SQRT(ALS/(PI*RATS))                                           A 376
      SR2=SR1*RATS                                                      A 379
C     *  CHECK TO SEE IF THE TOTAL BIAS ERROR IN RANGE IS = 0.0 OR IF   A 382
C     *  THE TOTAL BIAS ERROR IN DEFLECTION IS = 0.0                    A 383
      IF (T1.EQ.0.) T1=.00000001                                        A 384
      IF (T2.EQ.0.) T2=.00000001                                        A 385
      IF (A4.NE.0.0) GO TO 290                                          A 386
C     *  A3 = RADIUS OF TARGET, COMPUTE EQUIVALENT LENGTH AND WIDTH     A 387
      A3=SQRT(PI)*A3                                                    A 388
      A4=A3                                                             A 389
290   CONTINUE                                                          A 390
C                                                                       A 391
C     *  COMPUTE THE TARGET HALF DIMENSIONS                             A 392
C     *       A1 = TARGET HALF LENGTH                                   A 393
```

```
C     *       A2 = TARGET HALF WIDTH                                   A 394
C                                                                      A 395
      A1=A3*.5                                                         A 396
      A2=A4*.5                                                         A 397
C     *  SQUARE THE PRECISION ERROR IN RANGE AND DEFLECTION            A 398
      S1SQ=S1*S1                                                       A 399
      S2SQ=S2*S2                                                       A 400
C     *  MULTIPLY 2 BY EACH OF THE DAMAGE FUNCTION PARAMETERS          A 401
      TDS=2.0*DS                                                       A 402
      TDP=2.0*DP                                                       A 403
      TDC=2.0*DC                                                       A 404
C     *  COMPUTE Q1 AND Q2 FOR EACH POSTURE, I.E. STANDING: SSQ1 AND   A 405
C     *  SSQ2: PRONE: PSQ1 AND PSQ2: CROUCHING: CSQ1 AND CSQ2         A 406
      SSQ1=SQRT((SR1*SR1)/TDS+S1SQ)                                    A 407
      SSQ2=SQRT((SR2*SR2)/TDS+S2SQ)                                    A 410
C                                                                      A 413
C     *  COMPUTE THE MAXIMUM DEVIATION IN THE X (AJMX) AND Y (BJMX)    A 414
C     *  DIRECTIONS OF THE AIM POINTS OF THE ROUNDS FROM THE VOLLEY AIM A 415
C     *  POINT. I.E. DETERMINE THE HALF DIMENSIONS OF THE RECTANGLE    A 416
C     *  WHICH CONTAINS ALL THE HOWITIZER AIM POINTS                   A 417
C                                                                      A 418
      AJMX=ABS(SU1-A(1))                                               A 419
      BJMX=ABS(SU2-B(1))                                               A 420
C     *  DETERMINE IF MORE THAN 1 ROUND HAS BEEN ENTERED               A 421
      IF (N.EQ.1) GO TO 310                                            A 422
      DO 300 J=2,N                                                     A 423
      ASU1=ABS(SU1-A(J))                                               A 424
      BSU2=ABS(SU2-B(J))                                               A 425
      IF (ASU1.GT.AJMX) AJMX=ASU1                                      A 426
      IF (BSU2.GT.BJMX) BJMX=BSU2                                      A 427
  300 CONTINUE                                                         A 428
  310 CONTINUE                                                         A 429
```

```
C
C     *  CHECK TO SEE IF THE AIMPOINTS ARE SYMMETRIC ABOUT THE X AND/OR
C     *  Y AXES
C
      SSU3=0.0
      SSU4=0.0
      DO 320 J=1,N
      NJ1=N-J+1
      SSU3=SSU3+ABS(A(NJ1)+A(J))
      SSU4=SSU4+ABS(B(NJ1)+B(J))
320   CONTINUE
      SU3=SU1+SSU3
      SU4=SU2+SSU4
C     *  IF SU3 = 0.0, THEN THE BATTERY (OR HOWITIZER) AIMPOINTS ARE
C     *  SYMMERTIC ABOUT X (OR IN RANGE) AND THE SUMMATION OR INTERGAL
C     *  LIMIT IS U1.  IF SU3 IS NOT = 0.0 , THEN IT IS NOT SEMMERTIC
C     *  AND THE SUMMATION MUST BE TAKEN TO 2*U1
      IF (SU3.EQ.0.) GO TO 330
      U3=2.*U1
      GO TO 340
330   U3=U1
C     * IF SU4 = 0.0, THEN IT IS SYMMERTIC IN Y (OR DEFLECTION) AND THE
C     * SUMMATION OR INTERGRAL LIMIT IS U2.  IF SU4 IS NOT = TO 0.0,
C     *  THEN IT IS NOT SUMMERTIC AND THE SUMMATION MUST BE TAKEN TO
C     * 2*U2.
340   IF (SU4.EQ.0.) GO TO 350
      U4=2.*U2
      GO TO 360
350   U4=U2
360   CONTINUE
C     *  CONVERT THE SUMMATION LIMITS TO INTEGERS.
      LU3=U3
```

```
      LU4=U4
      TU1=T1*U1
      TU2=T2*U2
      AT1=A1/T1
      AT2=A2/T2
      IF (T1.EQ..00000001) GO TO -30
C
C     *  DETERMINE THE CENTERS OF THE INTEGRATION RECTANGLES BY
C     *  (X(J),Y(J))
C     *  SE1 AND SE2 ARE THE STEP SIZES IN THE X AND Y DIRECTIONS
C
      SE1=(-.+AT1)/U1
      SE12=SE1*.5
      AK=U3
      GO TO 380
370   AK=AK-1.
380   AX=FXJ(AK)
C     *  DETERMINE AK .LE. U3 SUCH THAT AA = H-'(AX,A1/T1) .GT. .0001
C     *  I.E. START WITH THE INTEGRATION LIMIT AND REDUCE IT BY 1 UNTIL
C     *  AA .GT. .0001
      CALL H (AX,AT1,HXL)
      AA=1.-HXL
      IF (AA.GT..0001) GO TO 390
      GO TO 370
390   SE3=(SE12+AX)/U1
      SE2=(-.+AT2)/U2
      SE22=SE2*.5
      AK=U4
      GO TO 410
400   AK=AK-1.
410   AY=FYJ(AK)
      CALL H (AY,AT2,HXL)
```

```
      AA=1.-H*L                                                          A 494
      IF (AA.GT..0001) GO TO 420                                         A 495
      GO TO 400                                                          A 496
  420 SE4=(SE22+AY)/2                                                    A 497
  430 IF (IFLAG.EQ.1) CALL Z100                                          A 498
      IF (IFLAG.EQ.1) GO TO 460                                          A 499
      IF (T1.EQ..00000001) GO TO 450                                     A 500
      GSE1=(AJMX+4.*SSQ1)/TL1                                            A 501
      GSE2=(BJMX+4.*SSQ2)/TL2                                            A 502
      SE12=AMIN1(SE3,GSE1)*.5                                            A 507
      SE22=AMIN1(SE4,GSE2)*.5                                            A 508
  450 CALL A50                                                           A 515
  460 CALL POST                                                          A 516
C
C
C
C THE FOLLOWING SUBROUTINES SEARCH VARIOUS AIMING POINT PATTERNS
C FOR THE CONTROL PARAMETERS WHICH PRODUCE OPTIMAL VALUES FOR
C EXPECTED TARGET COVERAGE FOR EACH PATTERN AGAINST EACH TARGET
C EVALUATED. SELECT DESIRED PATTERNS AND ELIMINATE CALL STATE-
C MENTS FOR THOSE NOT DESIRED.
C    PATA : 6 GUNS, PATTERNS 1 AND 2.
C    PATB : 6 GUNS, PATTERNS LAZY W, BCS HORIZONTAL, 3, 4, 5, AND 6.
C    PATC : 6 GUNS, PATTERNS BCS VERTICAL, 7, 8, 9, AND 10.
C    PATD : 4 GUNS, ALL PATTERNS.
C    PATE : 2 GUNS, ALL PATTERNS.
C
C
      CALL PATA
      CALL PATB
      CALL PATC
      CALL PATD
```

```
      CALL PATE
      WRITE (6,610)
470   CONTINUE                                                          A 517
      IF (IFLAG2.EQ.0) GO TO 110                                        A 518
      GO TO (120,130,150,160,170,180,190,200,210,220,240,500), IFLAG2   A 519
500   STOP                                                              A 524
C                                                                       A 525
510   FORMAT (8F10.5)                                                   A 526
515   FORMAT (4F10.5)
520   FORMAT (5F10.5)                                                   A 527
530   FORMAT (10I5)                                                     A 528
540   FORMAT (8X,3HNUM,6X,5HIFLAG,5X,5HNPOST,7X,1HN,8X,3HNVS,7X,3HNTS,7X A 529
     1,3HNRG,6X,4HNTLE/8I10)                                            A 530
550   FORMAT (/6X,2HU1,8X,2HU2,8X,3HSU1,7X,3HSU2,7X,3HREL,7X,2HDS,8X,2HD A 531
     1P,8X,2HDC,8X,2HTL,8X,2HTW/10F10.3)                                A 532
551   FORMAT (8X,33H(CIRCULAR ERROR PROBABLE - CEP'S))
552   FORMAT (13X,17H(PROBABLE ERRORS))
553   FORMAT (13X,21H(STANDARD DEVIATIONS))
555   FORMAT (/6X,2HU1,8X,2HU2,8X,3HSU1,7X,3HSU2,7X,3HREL,7X,2HDS,8X,2HD
     1P,8X,2HDC,8X,2HRT/9F10.3)
560   FORMAT (6X,3HPER,7X,3HPED,6X,4HMPIR,6X,4HMPID,6X,3HTLE,7X,3HALS,7X
     1,6HRATIOS/11F10.3)                                                A 534
570   FORMAT (/4X,3HET1,7X,3HET2,7X,2HW1,8X,2HW2,7X,3HCNB,7X,6HRELSUB/6F A 535
     110.3)                                                             A 536
580   FORMAT (/13H RANGE COORD       ,10(F5.0,2X))                      A 537
590   FORMAT (/13H DEFLECTION COORD  ,10(F5.3,2X))                      A 538
600   FORMAT (A1,9X,4F10.5)                                             A 539
610   FORMAT (1H1)                                                      A 540
620   FORMAT (41H  WATCH OUT FOR INTEGRATION SIZE IN RANGE)             A 541
630   FORMAT (46H  WATCH OUT FOR INTEGRATION SIZE IN DEFLECTION)        A 542
      END                                                               A 543-
*DECK A50
```

```
      SUBROUTINE A50
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION A(54), B(54)
      DIMENSION SZUM(50), PZUM(50), CZUM(50), SSUM(50), PSUM(50), CSUM(5
     10), NN(50), SZ(50), PZ(50), CZ(50)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM
      IF (T1.EQ..00000001) GO TO 170
      DO 110 I=1,NVS
  110 SZUM(I)=0.0
      DO 160 J=1,LU3
      DO 120 I=1,NVS
  120 SSUM(I)=0.0
      AJ=J
      X=FXJ(AJ)
      DO 140 K=1,LU4
      AK=K
      Y=FYJ(AK)
      CALL K6 (X,Y,SPK6)
      CALL FF (Y,SE22,AT2,1.,AF)
      DO 130 I=1,NVS
  130 SSUM(I)=SSUM(I)+(1.-(1.-SPK6)**NN(I))*AF
  140 CONTINUE
      CALL FF (Y,SE12,AT1,1.,AF)
      DO 150 I=1,NVS
  150 SZUM(I)=SZUM(I)+SSUM(I)*AF
  160 CONTINUE
  170 IF (T1.GT..00000001) GO TO 250
```

```
      SE1=A1/U1                                                 B  41
      SE12=SE1*.5                                               B  42
      SE2=A2/U2                                                 B  43
      SE22=SE2*.5                                               B  44
      DO 180 I=1,NVS                                            B  45
180   SZUM(I)=0.0                                               B  46
      DO 230 J=1,LU3                                            B  49
      DO 190 I=1,NVS                                            B  50
190   SSUM(I)=0.0                                               B  51
      AJ=J                                                      B  54
      Y=FXJ(AJ)                                                 B  55
      DO 210 K=1,LU4                                            B  56
      AK=K                                                      B  57
      Y=FYJ(AK)                                                 B  58
      CALL K6 (X,Y,SPKE)                                        B  59
      DO 200 I=1,NVS                                            B  60
200   SSUM(I)=SSUM(I)+(1.-(1.-SPKE)**NN(I))                     B  61
210   CONTINUE                                                  B  64
      DO 220 I=1,NVS                                            B  65
220   SZUM(I)=SZUM(I)+SSUM(I)/L4                                B  66
230   CONTINUE                                                  B  69
      DO 240 I=1,NVS                                            B  70
240   SZ(I)=SZUM(I)/U3                                          B  71
      RETURN                                                    B  74
250   TEMP=1.0                                                  B  75
      IF (SU3.EQ.1.) TEMP=2.0                                   B  76
      IF (SU4.EQ.0.) TEMP=2.0*TEMP                              B  77
      DO 260 I=1,NVS                                            B  78
260   SZ(I)=TEMP*SZUM(I)                                        B  79
      RETURN                                                    B  82
      END                                                       B  83-
*DECK A113
```

```
      SUBROUTINE A113 (AZ,BZ,XX,YY,P113)
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SC1,SC2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM
      LU5=40
      UU5=LU5
      VV5=0.0
      E5=2.*PI/UU5
      SK=VV5
      PSUM=0.
      DO 120 J=1,LU5
      IF (J.EQ.1) GO TO 110
      SK=SK+E5
110   SSK=SIN(SK)
      COSK=COS(SK)
      ZK=BZ*XX*COSK+AZ*YY*SSK+AZ*BZ
      CK=(AZ*COSK+XX)**2+(BZ*SSK+YY)**2
      XYZJ=Z113(CK)
      PSUM=PSUM+ZK*XYZJ/UU5
120   CONTINUE
      P113=PSUM
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK BIGG
      FUNCTION BIGG (T)
```

```
      S2=SQRT(2.)
      TA=T/S2
      BIGG=.5*(1.+ERF(TA))
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK DVDINT
      SUBROUTINE DVDINT (X,FX,XT,FT,NP,ND)
      DIMENSION XT(NP), FT(NP), T(15)
      N=ND
      N1=(N-1)/2
      N2=N/2
      N3=NP-N2+1
      IF (NP-N) 260,110,110
110   N4=N1+2
      IF (XT(1)-XT(2)) 120,340,270
120   CONTINUE
      IF (X-2.*XT(1)+XT(2)) 250,250,130
130   IF (X-2.*XT(NP)+XT(NP-1)) 140,140,250
140   IF (NP.LT.10) GO TO 160
      N5=NP-N
150   N5=N5/2
      N6=N4+N5
      IF (XT(N6).LT.X) N4=N6
      IF (N5.GT.1) GO TO 150
160   IF (X-XT(N4)) 190,170,170
170   IF (N4-N3) 180,190,180
180   N4=N4+1
      GO TO 160
190   N4=N4-1
      N5=N4-N1
```

```
      DO 200 I=1,N
      T(I)=FT(N5)
200   N5=N5+1
      L=(N+1)/2
      TR=T(L)
      N6=N4
      N7=N4+1
      JU=1
      N2=N-1
      UN=1.0
      DO 240 J=1,N2
      N5=N4-N1
      N3=N-J
      DO 210 I=1,N3
      N8=N5+J
      T(I)=(T(I+1)-T(I))/(XT(N8)-XT(N5))
210   N5=N5+1
      GO TO (220,230), JU
220   UN=UN*(X-XT(N6))
      JU=2
      N6=N6-1
      GO TO 240
230   UN=UN*(X-XT(N7))
      JU=1
      N7=N7+1
      L=L-1
240   TR=TR+UN*T(L)
      FX=TR
      RETURN
250   WRITE (6,350) X,XT(1),XT(NP)
      STOP
260   WRITE (6,360) NP,ND
```

```
      STOP
270   IF (X-2.*XT(1)+XT(2)) 280,250,250
280   IF (X-2.*XT(NP)+XT(NP-1)) 250,290,290
290   IF (NP.LT.10) GO TO 310
      N5=NP-N
300   N5=N5/2
      N6=N4+N5
      IF (XT(N6).GT.X) N4=N6
      IF (N5.GT.1) GO TO 300
310   IF (X-XT(N4)) 320,320,190
320   IF (N4-N3) 330,190,330
330   N4=N4+1
      GO TO 310
340   WRITE (6,370) XT(1)
      STOP
C
350   FORMAT (23H ARG. NOT IN TABLE   X= ,E14.7,9H   XT(1)= ,E14.7,10H   XT
     1(NP)= ,E14.7,2X,6HDVDINT)
360   FORMAT (22H TABLE TOO SMALL   NP= ,I5,6H   ND= ,I5,2X,6HDVDINT)
370   FORMAT (23H CONSTANT TABLE XT(1)= ,E14.7,2X,6HDVDINT)
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK ERF
      FUNCTION ERF (X)
      A=ABS(X)
      IF (A.GT.4.17) GO TO 110
      GO TO 120
110   ERF=1.0
      GO TO 150
120   IF (A.GT.1.51) GO TO 130
      GO TO 140
```

```
130    ERF=1.0-EXP(-A*A)*2.0*0.56-189584*(0.5*A/(A*A+0.5-(0.5/(A*A+2.5-(3   F  11
      1.0/(A*A+4.5-(7.5/(A*A+6.5-(10.803/(A*A+4.269))))))))))                F  12
       GO TO 150                                                            F  13
140    ERF=2.0*A*.56-189984*(1.0-1.0281*A*A/(A*A+10.216+(-167.17/(A*A+9.8   F  14
      1103+(231.39/(A*A+11.57+(71.228/(A*A-1.773+(64.229759/(A*A+5.577724   F  15
      25))))))))))                                                          F  16
150    IF (X.LT.0.0) ERF=-ERF                                               F  17
       RETURN                                                               F  18
       END                                                                  F  19-
C      ***///***///***///***///***///***///***///***///***///***///***///   G   1
C                                                                           G   2
*DECK FF
       SUBROUTINE FF (OX,OY,OL,S,AF)                                        G   3
       AF=0.                                                                G   4
       XPY=OX+OY                                                            G   5
       XMY=OX-OY                                                            G   6
       CALL H (XPY,OL,HXL)                                                  G   7
       E1=HXL                                                               G   8
       CALL H (XMY,OL,HXL)                                                  G   9
       E2=HXL                                                               G  10
       AF=E1-E2                                                             G  11
       RETURN                                                               G  12
       END                                                                  G  13-
C      ***///***///***///***///***///***///***///***///***///***///***///   H   1
C                                                                           H   2
*DECK FXJ
       FUNCTION FXJ (XX)                                                    H   3
       DIMENSION IPOST(10)                                                  H   4
       DIMENSION CAS(50), CNN(50)                                           H   5
       DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)               H   6
       COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,   H   7
      1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,   H   8
```

```
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMY,BJMY,TU1,TU2,SE3,SE4,NUM
      IF (XX.NE.0.) GO TO 110
      FXJ=0.
      GO TO 130
110   IF (SU3.NE.0.) GO TO 120
      FXJ=(2.*XX-1.)*SE12
      GO TO 130
120   FXJ=(2.*XX-1.-2.*U1)*SE12
130   RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK FYJ
      FUNCTION FYJ (XX)
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMY,BJMY,TU1,TU2,SE3,SE4,NUM
      IF (XX.NE.0.) GO TO 110
      FYJ=0.
      GO TO 130
110   IF (SU4.NE.0.) GO TO 120
      FYJ=(2.*XX-1.)*SE22
      GO TO 130
120   FYJ=(2.*XX-1.-2.*U2)*SE22
130   RETURN
```

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```
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK H
      SUBROUTINE H (YX,YL,HXL)
      HXL=0.
      IF (YL.EQ.0.) GO TO 110
      XPL=YX+YL
      XML=YX-YL
      X=XPL*BIGG(XPL)
      Y=XML*BIGG(XML)
      Z=SMG(XPL)
      Z1=SMG(XML)
      HXL=(X-Y+Z-Z1)/(2.*YL)
      GO TO 120
110   HXL=BIGG(YX)
120   RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK K6
      SUBROUTINE K6 (XX,YY,SPK6)
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION NN(50), SZ(50), PZ(50), CZ(50)
      DIMENSION A(54), B(54)
      DIMENSION XUA(54), YUB(54)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSJB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM
```

```
      SPKP=1.0
      DO 120 J=1,N
      IF (T1.EQ..00000001) GO TO 110
      XUA(J)=XX*T1+SU1-A(J)
      YUB(J)=YY*T2+SU2-B(J)
      GO TO 120
110   XUA(J)=XX+SU1-A(J)
      YUB(J)=YY+SU2-B(J)
120   CONTINUE
      IF (IFLAG.EQ.1) GO TO 140
      DO 130 J=1,N
      XTA=XUA(J)
      CALL PP (XTA,1,SPXJ)
      SPX1=SPXJ
      YTA=YUB(J)
      CALL PP (YTA,2,SPXJ)
      SPY1=SPXJ
      SPKP=SPKP*(1.-SPX1*SPY1*REL)
130   CONTINUE
      GO TO 180
140   DO 170 J=1,N
      XTA=XUA(J)/S1
      YTB=YUB(J)/S2
      CALL A113 (ES1,ES2,XTA,YTB,P113)
      PA=P113
      IF (WS1.EQ.0.0.AND.WS2.EQ.0.0) GO TO 150
      CALL A113 (WS1,WS2,XTA,YTB,P113)
      GO TO 160
150   P113=0.
160   SPKP=SPKP*(1.-SC45*(PA-P113))
170   CONTINUE
180   SPK6=1.-SPKP
```

```
      RETURN                                                            K  58
      END                                                               K  59-
C     ***///***///***///***///***///***///***///***///***///***///***/// L   1
C                                                                       L   2
*DECK POST
      SUBROUTINE POST                                                   L   3
      DIMENSION A(54), B(54)                                            L   4
      DIMENSION CAS(50), CNN(50), IPOST(10)                             L   5
      DIMENSION NN(50), FS(10,50), FP(10,50), FC(10,50), SZ(50), PZ(50), L   6
     1 CZ(50), ESS(50), ESP(50), ESC(50), SS(50), SP(50), SC(50), ESV(50 L   7
     2), VS(50), VP(50), VC(50), ECAS(10,50)                            L   8
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2, L   9
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1, L  10
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1 L  11
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL L  12
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM                 L  13
      COMMON /BLOCK2/ NCASLEV,CASIN(8)                                  L  14
C                                                                       L  15
C     POSTURE NO. 1  ALL STANDING                                       L  16
      DATA (FS(1,J),J=1,30)/30*1./,(FP(1,J),J=1,30)/30*0./,(FC(1,J),J=1, L  17
     130)/30*0./                                                        L  18
C                                                                       L  19
C     POSTURE NO. 2  ALL PRONE                                          L  20
      DATA (FS(2,J),J=1,30)/30*0./,(FP(2,J),J=1,30)/30*1./,(FC(2,J),J=1, L  21
     130)/30*0./                                                        L  22
C                                                                       L  23
C     POSTURE NO. 3  ALL CROUCHING IN FOXHOLE                           L  24
      DATA (FS(3,J),J=1,30)/30*0./,(FP(3,J),J=1,30)/30*0./,(FC(3,J),J=1, L  25
     130)/30*1./                                                        L  26
C                                                                       L  27
C      *  POSTURE NO. 4: 1ST VOLLEY - .5/.5/0.; ALL OTHERS - 0./1./0.   L  28
C                                                                       L  29
```

```
      DATA (FS(4,J),J=1,30)/.5,29*0./,(FP(4,J),J=1,30)/.5,29*1./,(FC(4,J
     1),J=1,30)/30*0./
C
C     *  POSTURE NO. 5: 1ST VOLLEY - 0./.5/.5: ALL OTHERS - 0./0./1.
C
      DATA (FS(5,J),J=1,30)/30*0./,(FP(5,J),J=1,30)/.5,29*0./,(FC(5,J),J
     1=1,30)/.5,29*1./
C
C     *  POSTURE NO. 6: 1ST VOLLEY - .5/.5/0.: ALL OTHERS - 0./0./1.
C
      DATA (FS(6,J),J=1,30)/.5,29*0./,(FP(6,J),J=1,30)/.5,29*0./,(FC(6,J
     1),J=1,30)/0.,29*1./
C
C     *  POSTURE NO. 7: ALL VOLLEYS - 1./0./0.
      DATA (FS(7,J),J=1,30)/30*1./,(FP(7,J),J=1,30)/30*0./,(FC(7,J),J=1,
     130)/30*0./
C
C     POSTURE NO. 8 1ST VOLLEY- .5/.5/0  ALL OTHERS - 0/.35/.65
      DATA (FS(8,J),J=1,30)/.5,29*0./,(FP(8,J),J=1,30)/.5,29*.35/,(FC(8,
     1J),J=1,30)/0.,29*.65/
C
C     POSTURE NO. 9  ALL VOLLEYS  0/.35/.65/
      DATA (FS(9,J),J=1,30)/30*0./,(FP(9,J),J=1,30)/30*.35/,(FC(9,J),J=1
     1,30)/30*.65/
C
C     POSTURE NO. 10  1ST VOLLEY- .50/.50/0.  ALL OTHERS - 0/.75/.25
      DATA (FS(10,J),J=1,30)/.50,29*0./,(FP(10,J),J=1,30)/.50,29*.75/,(F
     1C(10,J),J=1,30)/0.,29*.25/
C
      I=1
      IF (IPOST(I).NE.0) GO TO 100
      WRITE (6,245)
```

```
      DO 50 I=1,NVS
50    WRITE (6,230) NN(I),SZ(I)
      GO TO 210
100   DO 110 I=1,NVS
110   ESS(I)=1.-SZ(I)                                           L  62
      DO 150 L=1,NPOST                                          L  65
      I=IPOST(L)                                                L  66
      SS(1)=FS(I,1)*ESS(1)                                      L  67
      SP(1)=FP(I,1)*ESP(1)                                      L  68
      SC(1)=FC(I,1)*ESC(1)                                      L  69
      ESV(1)=SS(1)+SP(1)+SC(1)                                  L  70
      ECAS(L,1)=1.-ESV(1)                                       L  71
      J=1                                                       L  72
      DO 150 J=2,NVS                                            L  73
      K=J-1                                                     L  74
      IF (FS(I,K).NE.0.) GO TO 120                              L  75
      VS(J)=0.0
      GO TO 125
120   VS(J)=SS(K)*(FS(I,J)/FS(I,K))                             L  77
125   T=FP(I,J)-FS(I,K)+FS(I,J)
      IF (T.LT.0.) GO TO 130                                    L  79
      IF (FP(I,K).EQ.0.) VP(J)=SS(K)-VS(J)                      L  80
      IF (FP(I,K).GT.0.) VP(J)=SS(K)-VS(J)+SP(K)*T/FP(I,K)      L  81
      GO TO 140                                                 L  82
130   VP(J)=SS(K)*FP(I,J)/FS(I,K)                               L  83
140   VC(J)=ESV(K)-VP(J)-VS(J)                                  L  84
      SS(J)=VS(J)*ESS(J)/ESS(K)                                 L  85
      SP(J)=VP(J)*ESP(J)/ESP(K)                                 L  86
      SC(J)=VC(J)*ESC(J)/ESC(K)                                 L  87
      ESV(J)=SS(J)+SP(J)+SC(J)                                  L  88
      ECAS(L,J)=1.-ESV(J)                                       L  89
150   CONTINUE                                                  L  90
```

```
      WRITE (6,240)
      WRITE (6,250) (IPOST(J),J=1,NPOST)
160   DO 170 I=1,NVS
170   WRITE (6,290) NN(I),SZ(I),SZ(I),SZ(I),(ECAS(J,I),J=1,NPOST)
      CASLEV=CASIN(1)
      IF (CASLEV.EQ.0.) GO TO 210
      DO 200 NCAS=1,NCASLEV
      CASLEV=CASIN(NCAS)
      WRITE (6,260)
      DO 200 I=1,NPOST
      DO 180 J=1,NVS
180   CAS(J)=ECAS(I,J)
      CN=N
      IF (CASLEV.GT.CAS(NVS)) GO TO 220
      IF (CASLEV.LE.CAS(1)) GO TO 230
      ND=3
      CALL DVDINT (CASLEV,ENV,CAS,CNN,NVS,ND)
190   ENR=CN*ENV
      WRITE (6,300) IPOST(I),ENR,CASLEV
200   CONTINUE
210   NUM=NUM+1
      WRITE (6,270)
      RETURN
220   WRITE (6,280) IPOST(I),CASLEV,NN(NVS)
      GO TO 200
230   ENV=CNN(1)
      GO TO 190
C
240   FORMAT (///7H VOL SZ,2X,6HSTAND ,3X,5HPRONE,2X,6HCROUCH,2X,17H   PO
     1STURE  NUMBER)
245   FORMAT (///7H VOL SZ,2X,3HCAV)
250   FORMAT (33X,10(I3,5X))
```

```
260    FORMAT (1H0)                                                          L 122
270    FORMAT (1H1)                                                          L 123
280    FORMAT (13H POSTURE NO  ,I4,2X,F4.2,25H CAN NOT BE ACHIEVED WITH,I    L 124
      13,8H VOLLEYS)                                                         L 125
290    FORMAT (I5,15(2X,F7.5))                                               L 126
300    FORMAT (12H POSTURE NO ,I3,5X,F10.5,35H IS THE EXPECTED NO OF RDS     L 127
      1FOR THE ,F4.2,5X,6H LEVEL)                                            L 128
       END                                                                   L 129-
*DECK PP
       SUBROUTINE PP (X,J,SPXJ)                                              M   1
       DIMENSION IPOST(10)                                                   M   2
       DIMENSION CAS(50), CNN(50)                                            M   3
       DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)                M   4
       COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,    M   5
      1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,    M   6
      2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1    M   7
      3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CN3,U3,U4,WS1,WS2,CASL    M   8
      4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM                     M   9
       SPXJ=0.                                                               M  10
       IF (J.EQ.2) GO TO 130                                                 M  13
       SSQ7=7.*SSQ1                                                          M  14
       IF (X.GT.SSQ7) GO TO 160                                              M  17
       SPXJ=SR1/SSQ1*EXP(-(X/SSQ1)**2*.5)/SQR2                               M  18
       GO TO 160                                                             M  23
130    SSQ8=7.*SSQ2                                                          M  24
       IF (X.GT.SSQ8) GO TO 160                                              M  27
       SPXJ=SR2/SSQ2*EXP(-(X/SSQ2)**2*.5)/SQR2                               M  28
160    RETURN                                                                M  33
       END                                                                   M  34-
C      ***///***///***///***///***///***///***///***///***///***///***///    N   1
C                                                                            N   2
*DECK SMG
```

```
      FUNCTION SMG (X)
      PI=3.14159265
      PI2=PI*2.0
      SMG=0.0
      XX=-(X*X*0.5)
      IF (XX.GT.-30.0) GO TO 110
      AAA=EXP(XX)
      SMG=AAA/SQRT(PI2)
110   RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK Z100
      SUBROUTINE Z100
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQP2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM
      SC45=REL
      PC45=REL
      CC45=REL
      SW1=SQRT(W1*W2)
      SW2=SQRT(ET1*ET2)
      WS1=W1/S1
      WS2=W2/S2
      ES1=ET1/S1
      ES2=ET2/S2
      SW12=SW1*SW1
```

```
      SW22=SW2*SW2
      SWSW=SW22-SW12
      SSRR=RELSQ3*SR1*SR2
      IF (T1.EQ.0.00000001) GO TO 110
      GSE1=(AJM1+2T1+4.*S1)/TL1
      GSE2=(BJM1+2T2+4.*S2)/TL2
      SE12=AMIN1(SF3,GSE1)*.5
      SE22=AMIN1(SE4,GSE2)*.5
110   TEMP=SSRR*CNB/SWSW
      IF (TEMP.GT.-0.0) GO TO 120
      SC45=REL*(1.-(EXP(-TEMP)))
120   TEMP=PSRR*CNB/SWSW
      IF (TEMP.GT.-0.0) GO TO 130
      PC45=REL*(1.-(EXP(-TEMP)))
130   TEMP=CSRR*CNB/SWSW
      IF (TEMP.GT.-0.0) GO TO 140
      CC45=REL*(1.-(EXP(-TEMP)))
140   CALL AF1
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK Z113
      FUNCTION Z113 (SO)
      IF (SO.LT.150.0) GO TO 110
      Z113=1.0/SO
      GO TO 130
110   CONTINUE
      IF (SO.LE..001) GO TO 120
      Z113=(1.-EXP(-SO/2.))/SO
      GO TO 130
120   Z113=.5-SO/8.+SO**2/48.
```

```
130     RETURN                                                                  P  12
        END                                                                     P  13-
C       ***///***///***///***///***///***///***///***///***///***///***///      P   1
C
*DECK EXX
        FUNCTION EXX (ZZ)                                                       Q   1
        IF (ZZ.GT.-25.) GO TO 110                                               Q   2
        EXX=0.                                                                  Q   3
        RETURN                                                                  Q   4
110     CONTINUE                                                                Q   5
        EXX=EXP(ZZ)                                                             Q   6
        RETURN                                                                  Q   7
        END                                                                     Q   8-
C       ***///***///***///***///***///***///***///***///***///***///***///      P   1
C
*DECK EVAL
        SUBROUTINE EVAL
        DIMENSION IPOST(10)
        DIMENSION CAS(50), CNN(50)
        DIMENSION DTYPE(10)
        DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
        DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
       1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
       210), EET1(10), EET2(10), WW1(10), WW2(10)
        COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
       1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
       2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
       3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
       4EV,CAS,RELSJB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
       5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
        REAL MPIR,MPID,LL,LD
        AJMX=ABS(SU1-A(1))
```

```
      BJMX=ABS(SU2-B(1))
      IF(N.EQ.1) GOTO 20
      DO 10 J=2,N
      ASU1=ABS(SU1-A(J))
      BSU2=ABS(SU2-B(J))
      IF (ASU1.GT.AJMX) AJMX=ASU1
      IF (BSU2.GT.BJMX)BJMX=BSU2
10    CONTINUE
20    GSE1=(AJMX+4.*SSQ1)/TU1
      GSE2=(BJMX+4.*SSQ2)/TU2
      SE12=AMIN1(SE3,GSE1)*.5
      SE22=AMIN1(SE4,GSE2)*.5
      CALL A50
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///
C
*DECK GOLD
      SUBROUTINE GOLD
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PP1,PP2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,PELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
```

```
      REAL MPIR,MPID,LL,LD
      GOTO(10,20,30)IGOLD
10    UD=LL+(.618*UL)
      D=UD
      IGOLD=2
      INEW=2
      RETURN
20    LD=LL+(.618*UD)
      D=LD
      IGOLD=3
      INEW=3
      RETURN
30    IF(FUD.GE.FLD)GOTO 40
      UL=UD
      UD=LD
      LD=UL-UD+LL
      D=LD
      INEW=1
      RETURN
40    LL=LD
      LD=UD
      UD=UL-LD+LL
      D=UD
      INEW=2
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
C
*DECK PATA
      SUBROUTINE PATA
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
```

```
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
      REAL MPIR,MPID,LL,LD
C     *  PRINT HEADING FOR PATTERN NUMBER 1
      WRITE (6,10)
10    FORMAT (1H1)
      WRITE (6,20)
20    FORMAT (/17H PATTERN NUMBER 1)
      WRITE (6,30)
30    FORMAT (//4X,24H DISTANCE BETWEEN ROUNDS,3X,18H EXPECTED COVERAGE/
     1)
      FLD=0.
      FUD=0.
      INEW=1
40    GOTO(50,70,80,90) INEW
50    DO 60 I=1,5
60    A(I)=0.
      LD=0.
      LL=0.
      UL=A4/3.09
      IGOLD=1
      CALL GOLD
      GOTO 100
```

```
70    FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      GOTO 100
80    FLD=SZ(1)
      CALL GOLD
      GOTO 100
90    FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      GOTO 100
100   B(1)=D*(-2.5)
      B(2)=D*(-1.5)
      B(3)=D*(-.5)
      B(4)=D*.5
      B(5)=D*1.5
      B(6)=D*2.5
      CALL EVAL
      WRITE (6,110) D,SZ(1)
110   FORMAT (9X,F5.1,7H METERS,13X,F7.5)
      IF (UD-LD.GT.1.) GOTO 40
C   *  PRINT HEADING FOR PATTERN NUMBER 2
105   WRITE (6,10)
      WRITE (6,120)
120   FORMAT (/17H PATTERN NUMBER 2)
      WRITE (6,30)
      FLD=0.
      FUD=0.
      INEW=1
140   GOTO(150,170,180,190) INEW
150   DO 160 I=1,6
160   B(I)=0.
```

```
      LD=0.
      LL=0.
      UL=A3/3.09
      IGOLD=1
      CALL GOLD
      GOTO 200
170   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      GOTO 200
180   FLD=SZ(1)
      CALL GOLD
      GOTO 200
190   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      GOTO 200
200   A(1)=D*(-2.5)
      A(2)=D*(-1.5)
      A(3)=D*(-.5)
      A(4)=D*.5
      A(5)=D*1.5
      A(6)=D*2.5
      CALL EVAL
      WRITE (6,110) D,SZ(1)
      IF (UD-LD.GT.1.) GOTO 1-0
      DO 210 I=1,6
      A(I)=0.
210   B(I)=0.
      RETURN
      END
C     ***///***///***///***///***///***///***///***///***///***///***///
```

```
C
*DECK PAT3
      SUBROUTINE PAT3
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,N3,CNN,TTT,CN3,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSU3,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,JL
      REAL MPIR,MPID,LL,LD
C     *  EVALUATE FOR LAZY W HORIZONTAL
      GOTO 8
5     WRITE (6,7)
7     FORMAT (//5X,5HERROR)
      RETURN
8     WRITE (6,10)
10    FORMAT (1H1)
      A(1)=A(2)=A(3)=25.
      A(4)=A(5)=A(6)=-25.
      B(1)=-125.
      B(2)=-25.
      B(3)=75.
      B(4)=-75.
      B(5)=25.
      B(6)=125.
```

```
      CALL EVAL
      WRITE (6,12) SZ(1)
12    FORMAT (//5X,34H  EXPECTED COVERAGE FOR "LAZY W" :,F10.5)
C     *  PRINT HEADING FOR BCS HORIZONTAL
      WRITE (6,15)
15    FORMAT (/15H BCS HORIZONTAL)
      WRITE (6,30)
30    FORMAT (//4X,9H D(RANGE),15H  D(DEFLECTION),19H  EXPECTED COVERAGE
     1)
C     *  EVALUATE BCS HORIZONTAL AND ESTABLISH START POINT FOR PAT3
      B(2)=B(5)=0.
      D1=A3/2.
      D2=A4/3.
      BD1=D1
      A(1)=A(2)=A(3)=.5*D1
      A(4)=A(5)=A(6)=-.5*D1
      B(1)=B(4)=-D2
      B(3)=B(6)=D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
110   FORMAT (4X,F6.1,6X,F6.1,12X,F7.5)
C     *  EVALUATE FOR PATTERN NUMBER 3
      WRITE (6,32)
32    FORMAT (//17H PATTERN NUMBER 3)
      WRITE (6,30)
      IPAT=3
C     *  DO LINE SEARCH ON D2
35    FLD=0.
      FUD=0.
      INEW=1
40    GOTO(50,60,70,80)INEW
50    LD=0.
```

```
      LL=0.
      UL=A4/2.
      IGOLD=1
      CALL GOLD
      D2=D
      GOTO (5,5,150,430,470,520)IPAT
60    FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,150,430,470,520)IPAT
70    FLD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,150,430,470,520)IPAT
80    FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,150,430,470,520)IPAT
150   B(1)=B(4)=-D2
      B(3)=B(6)=D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
235   FLD=0.
      FUD=0.
      INEW=1
240   GOTO(250,260,270,280)INEW
250   LD=0.
      LL=0.
```

```
      JL=A3
      IGOLD=1
      CALL GOLD
      D1=0
      GOTO (5,5,300,-20,480,530)IPAT
260   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D1=0
      GOTO (5,5,300,-20,480,530)IPAT
270   FLD=SZ(1)
      CALL GOLD
      D1=0
      GOTO (5,5,300,-20,480,530)IPAT
280   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D1=0
      GOTO (5,5,300,-20,480,530)IPAT
300   A(1)=A(2)=A(3)=.5*D1
      A(4)=A(5)=A(6)=-.5*D1
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 240
      IF (ABS(SD1-D1).LE.1.) GOTO 310
      SD1=D1
      GOTO 35
C     *  EVALUATE FOR PATTERN NUMBER 4
310   LIM=0
      WRITE (6,10)
      WRITE (6,320)
320   FORMAT (//17H PATTERN NUMBER 4)
```

```
      WRITE (6,325)
325   FORMAT (//4X,9H D(RANGE),19H  D(DEFLECTION),11H  D(CENTER),19H  EX
     1PECTED COVERAGE)
      IPAT=1
      DD3=D1
C     *  DO LINE SEARCH ON D3
335   FLD=0.
      FUD=0.
      INEW=1
340   GOTO(350,360,370,380)INEW
350   LO=0.
      LL=0.
      UL=A3
      IGOLD=1
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
360   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
370   FLD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
380   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
400   A(2)=.5*D3
```

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```
      A(5)=-.5*D3
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
410   FORMAT (4X,F6.1,6X,F6.1,7X,F6.1,12X,F7.3)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 450
      IF (UD-LD.GT.1.)GOTO 340
      IF (ABS(B03-D3).LE.1.) GOTO 450
      B03=D3
      GOTO 335
420   A(1)=A(3)=.5*D1
      A(4)=A(6)=-.5*D1
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF(LIM.GE.100) GOTO 450
      IF (UD-LD.GT.1.) GOTO 240
      GOTO 35
430   B(1)=B(4)=-D2
      B(3)=B(6)=D2
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 450
      IF (UD-LD.GT.1.) GOTO 40
      GOTO 335
C     *  EVALUATE FOR PATTERN NUMBER 5
450   WRITE (6,10)
      WRITE (6,460)
460   FORMAT (/17H PATTERN NUMBER 5)
      WRITE (6,30)
      IPAT=5
```

```
      BD1=A3/2.
      A(1)=A(2)=A(3)=A3/4.
      A(4)=A(5)=A(6)=-A3/4
C     *  DO LINE SEARCH ON D2
      GOTO 35
470   B(1)=-1.25*D2
      B(2)=-.25*D2
      B(3)=.75*D2
      B(4)=-.75*D2
      B(5)=.25*D2
      B(6)=1.25*D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
      GOTO 230
480   A(1)=A(2)=A(3)=.5*D1
      A(4)=A(5)=A(6)=-.5*D1
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 240
      IF (ABS(BD1-D1).LE.1.) GOTO 500
      BD1=D1
C     *  EVALUATE FOR PATTERN NUMBER 6
500   IPAT=6
      LIM=0
      A(2)=A(5)=0.
      B(2)=-1.
      B(5)=1.
      BD3=2.
      WRITE (6,10)
      WRITE (6,510)
```

```
510   FORMAT (//16H PATTERN NUMBER 6)
      WRITE (6,325)
      CALL EVAL
      WRITE (6,410) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
C     *  DO LINE SEARCH ON D2
      GOTO 35
520   B(1)=-1.25*D2
      B(3)=.75*D2
      B(4)=-.75*D2
      B(6)=1.25*D2
      CALL EVAL
      WRITE (6,410) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
      GOTO 235
530   A(1)=A(3)=.5*D1
      A(4)=A(6)=-.5*D1
      CALL EVAL
      WRITE (6,410) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 240
C     *  DO LINE SEARCH ON D3
      GOTO 335
540   B(2)=-.5*D3
      B(5)=.5*D3
      CALL EVAL
      WRITE (6,410) D1,D2,D3,SZ(1)
```

```
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 340
      IF (ABS(BD3-D3).LE.1.) GOTO 550
      BD3=D3
      GOTO 35
550   DO 560 I=1,3
      A(I)=0.
560   B(I)=0.
      RETURN
      END
C
C     ***///***///***///***///***///***///***///***///***///***///***///
C
C
*DECK PATC
      SUBROUTINE PATC
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
      REAL MPIR,MPID,LL,LD
      GOTO 12
```

```
5     WRITE (6,7)
7     FORMAT (//5X,5HERROR)
      RETURN
C     *  PRINT HEADING FOR BCS VERTICAL
10    FORMAT (1H1)
12    WRITE (6,15)
15    FORMAT (/13H BCS VERTICAL)
      WRITE (6,30)
30    FORMAT (//4X,8H  D(DEF) ,15H     D(RANGE)  ,19H  EXPECTED COVERAGE
     1)
C     *  EVALUATE BCS VERTICAL AND ESTABLISH START POINT FOR PAT3
      A(2)=A(5)=0.
      D1=A4/2.
      D2=A3/3.
      BD1=D1
      B(1)=B(2)=B(3)=.5*D1
      B(4)=B(5)=B(6)=-.5*D1
      A(1)=A(4)=-D2
      A(3)=A(6)=D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
110   FORMAT (4X,F6.1,6X,F6.1,12X,F7.5)
C     *  EVALUATE FOR PATTERN NUMBER 7
      WRITE (6,32)
32    FORMAT (//17H PATTERN NUMBER 7)
      WRITE (6,30)
      IPAT=3
C     *  DO LINE SEARCH ON D2
35    FLD=0.
      FUD=0.
      INEW=1
40    GOTO(50,60,70,80)INEW
```

```
50    LD=0.
      LL=0.
      UL=A3/2.
      IGOLD=1
      CALL GOLD
      D2=0
      GOTO (5,5,150,430,470,520)IPAT
60    FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D2=0
      GOTO (5,5,150,430,470,520)IPAT
70    FLD=SZ(1)
      CALL GOLD
      D2=0
      GOTO (5,5,150,430,470,520)IPAT
80    FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D2=0
      GOTO (5,5,150,430,470,520)IPAT
150   A(1)=A(4)=-D2
      A(3)=A(6)=D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
235   FLD=0.
.     FUD=0.
      INEW=1
240   GOTO(250,260,270,280)INEW
250   LD=0.
```

```
      LL=0.
258   UL=A+
259   IGOLD=1
      CALL GOLD
      D1=D
      GOTO (5,5,300,420,480,530)IPAT
260   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D1=D
      GOTO (5,5,300,420,480,530)IPAT
270   FLD=SZ(1)
      CALL GOLD
      D1=D
      GOTO (5,5,300,420,480,530)IPAT
280   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D1=D
      GOTO (5,5,300,420,480,530)IPAT
300   B(1)=B(2)=B(3)=.5*D1
      B(4)=B(5)=B(6)=-.5*D1
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 250
      IF (ABS(BD1-D1).LE.1.) GOTO 310
      BD1=D1
      GOTO 35
C     *  EVALUATE FOR PATTERN NUMBER 8
310   LIM=0
      WRITE (6,10)
      WRITE (6,320)
```

```
320   FORMAT (//17H PATTERN NUMBER 8)
      WRITE (6,325)
325   FORMAT (//4X,9H  D(DEF) ,15H      D(RANGE)  ,11H  D(CENTER),19H  EX
     1PECTED COVERAGE)
      IPAT=4
      D3=D1
C     *  DO LINE SEARCH ON D3
335   FLD=0.
      FUD=0.
      INEW=1
340   GOTO(350,360,370,380)INEW
350   LD=0.
      LL=0.
      UL=4.
      IGOLD=1
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
360   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
370   FLD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
380   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D3=D
      GOTO (5,5,5,400,5,540)IPAT
```

```
400    B(2)=.5*D3
       B(5)=-.5*D3
       CALL EVAL
       WRITE (6,-10) D1,D2,D3,SZ(1)
       LIM=LIM+1
       IF (LIM.GE.100) GOTO 450
410    FORMAT (4X,F6.1,6X,F6.1,7X,F6.1,12X,F7.3)
       IF (UD-LD.GT.1.)GOTO 340
       IF (ABS(BD3-D3).LE.1.) GOTO 430
       BD3=D3
       GOTO 235
420    B(1)=B(3)=.5*D1
       B(4)=B(6)=-.5*D1
       CALL EVAL
       WRITE (6,-10) D1,D2,D3,SZ(1)
       LIM=LIM+1
       IF (LIM.GE.100) GOTO 450
       IF (UD-LD.GT.1.) GOTO 240
       GOTO 3[illegible]
430    A(1)=A(4)=-D2
       A(3)=A(6)=D2
       CALL EVAL
       WRITE (6,-10) D1,D2,D3,SZ(1)
       LIM=LIM+1
       IF (LIM.GE.100) GOTO 450
       IF (UD-LD.GT.1.) GOTO 40
       GOTO 335
C      *  EVALUATE FOR PATTERN NUMBER 9
450    WRITE (6,10)
       WRITE (6,460)
460    FORMAT (/17H PATTERN NUMBER 9)
       WRITE (6,30)
```

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```
      IPAT=5
      BD1=A4/2.
      B(1)=B(2)=B(3)=A4/4.
      B(4)=B(5)=B(6)=-A4/4
C     *  DO LINE SEARCH ON D2
      GOTO 35
470   A(1)=-1.25*D2
      A(2)=-.25*D2
      A(3)=.75*D2
      A(4)=-.75*D2
      A(5)=.25*D2
      A(6)=1.25*D2
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
      GOTO 235
480   B(1)=B(2)=B(3)=.5*D1
      B(4)=B(5)=B(6)=-.5*D1
      CALL EVAL
      WRITE (6,110) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 240
      IF (ABS(BD1-D1).LE.1.) GOTO 500
      BD1=D1
C     *  EVALUATE FOR PATTERN NUMBER 10
500   LIM=0
      IPAT=6
      B(2)=B(5)=0.
      A(2)=-1.
      A(5)=1.
      BD3=2.
      WRITE (6,10)
```

```
      WRITE (6,510)
510   FORMAT (//18H PATTERN NUMBER 10)
      WRITE (6,325)
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
C     *  DO LINE SEARCH ON D2
      GOTO 35
520   A(1)=-1.25*D2
      A(3)=.75*D2
      A(4)=-.75*D2
      A(6)=1.25*D2
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 40
C     *  DO LINE SEARCH ON D1
      GOTO 235
530   B(1)=B(3)=.5*D1
      B(4)=B(6)=-.5*D1
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
      LIM=LIM+1
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 240
C     *  DO LINE SEARCH ON D3
      GOTO 335
540   A(2)=-.5*D3
      A(5)=.5*D3
      CALL EVAL
      WRITE (6,-10) D1,D2,D3,SZ(1)
      LIM=LIM+1
```

```
      IF (LIM.GE.100) GOTO 550
      IF (UD-LD.GT.1.) GOTO 340
      IF (ABS(BD3-D3).LE.1.) GOTO 550
      BD3=D3
      GOTO 35
550   DO 560 I=1,6
      A(I)=0.
560   B(I)=0.
      RETURN
      END
C
C     ***///***///***///***///***///***///***///***///***///***///***///
C
C
*DECK PATD
      SUBROUTINE PATD
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(54), B(54), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,NB,CNN,TTT,CNB,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TU1,TU2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INEW,LD,LL,UD,UL
      REAL MPIR,MPID,LL,LD
      GOTO 8
5     WRITE (6,7)
```

```
7      FORMAT (//5X,5HERROR)
       RETURN
C    *  PRINT HEADING FOR PATTERN NUMBER 1
8      WRITE (6,10)
10     FORMAT (1H1)
       WRITE (6,20)
20     FORMAT (/17H PATTERN NUMBER 1)
       WRITE (6,30)
30     FORMAT (//5X,24H DISTANCE BETWEEN ROUNDS,5X,18H EXPECTED COVERAGE/
      1)
       FLD=0.
       FUD=0.
       INEW=1
40     GOTO(50,70,80,90) INEW
50     DO 60 I=1,4
60     A(I)=0.
       LO=0.
       LL=0.
       UL=A4/1.8
       IGOLD=1
       CALL GOLD
       GOTO 100
70     FLD=FUD
       FUD=SZ(1)
       CALL GOLD
       GOTO 100
80     FLD=SZ(1)
       CALL GOLD
       GOTO 100
90     FUD=FLD
       FLD=SZ(1)
       CALL GOLD
```

```
      GOTO 100
100   B(1)=D*(-1.0)
      B(2)=D*(-.5)
      B(3)=D*.5
      B(4)=D*1.0
      CALL EVAL
      WRITE (6,110) D,SZ(1)
110   FORMAT (1X,F5.1,7H METERS,1X,F7.3)
      IF (UD-LD).GT.1.) GOTO 40
C     *  PRINT HEADING FOR PATTERN NUMBER 2
105   WRITE (6,10)
      WRITE (6,120)
120   FORMAT (/17H PATTERN NUMBER 2)
      WRITE (6,20)
      FLD=0.
      FUD=0.
      INEW=1
140   GOTO(150,170,180,190) INEW
150   DO 160 I=1,5
160   B(I)=0.
      LD=0.
      LL=0.
      UL=A3/1.8
      IGOLD=1
      CALL GOLD
      GOTO 200
170   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      GOTO 200
180   FLD=SZ(1)
      CALL GOLD
```

```
      GOTO 100
190   FOD=FLD
      FLD=SZ(1)
      CALL GOLD
      GOTO 200
200   A(1)=D*(-1.5)
      A(2)=D*(-.5)
      A(3)=D*.5
      A(4)=D*1.5
      CALL EVAL
      WRITE (6,110) D,SZ(1)
      IF (UD-LD.GT.1.) GOTO 140
C     *  PRINT HEADING FOR BCS
      WRITE (6,315)
315   FORMAT (/13H BCS PATTERN)
      WRITE (6,330)
330   FORMAT (//-X,9H D(RANGE),15H  D(DEFLECTION),19H  EXPECTED COVERAGE
     1)
C     *  EVALUATE BCS AND ESTABLISH START POINT FOR PAT4
      D1=A3/2.
      D2=A4/2.
      BD1=D1
      A(1)=A(2)=.5*D1
      A(3)=A(4)=-.5*D1
      B(1)=B(3)=-.5*D2
      B(2)=B(4)=.5*D2
      CALL EVAL
      WRITE (6,410) D1,D2,SZ(1)
410   FORMAT (-X,F6.1,8X,F6.1,12X,F7.5)
C     *  EVALUATE FOR PATTERN NUMBER 3
      WRITE (6,332)
332   FORMAT (//17H PATTERN NUMBER 3)
```

```
      WRITE (6,330)
      IPAT=3
C     *  DO LINE SEARCH ON D2
335   FLD=0.
      FUD=0.
      INEW=1
340   GOTO(350,360,370,380)INEW
350   LD=0.
      LL=0.
      UL=10
      IGOLD=1
      CALL GOLD
      D2=D
      GOTO (5,5,450,770)IPAT
360   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,450,770)IPAT
370   FLD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,450,770)IPAT
380    FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D2=D
      GOTO (5,5,450,770)IPAT
450   B(1)=B(3)=-.5*D2
      B(2)=B(4)=.5*D2
      CALL EVAL
      WRITE (6,410) D1,D2,SZ(1)
```

```
      IF (UD-LD.GT.1.) GOTO 540
C     *  DO LINE SEARCH ON D1
538   FLD=0
      FUD=0
      INEW=1
540   GOTO(550,560,570,580)INEW
550   LD=0.
      LL=0.
      UL=A3
      IGOLD=1
      CALL GOLD
      D1=D
      GOTO ([illegible],600,780)IPAT
560   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      D1=D
      GOTO ([illegible],600,780)IPAT
570   FLD=SZ(1)
      CALL GOLD
      D1=D
      GOTO ([illegible],600,780)IPAT
580   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      D1=D
      GOTO ([illegible],600,780)IPAT
600   A(1)=A(2)=.5*D1
      A(3)=A(4)=-.5*D1
      CALL EVAL
      WRITE (6,-1[illegible]) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 540
```

```
      IF (ABS(BD1-D1).LE.1.) GOTO 780
      BD1=D.
      GOTO 335
C     *  EVALUATE FOR PATTERN NUMBER 4
750   WRITE (6,10)
      WRITE (6,760)
760   FORMAT (/,17H PATTERN NUMBER 4)
      WRITE (6,700)
      IPAT=4
      BD1=A3/2.
      A(1)=A(3)=0.
      A(2)=A3/4.
      A(4)=-A3/4.
C     *  DO LINE SEARCH ON D2
      GOTO 345
770   B(1)=-.5*D2
      B(2)=B(4)=0.
      B(3)=.5*D2
      CALL EVAL
      WRITE (6,410) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 340
C     *  DO LINE SEARCH ON D1
      GOTO 335
780   A(2)=.5*D1
      A(4)=-.5*D1
      CALL EVAL
      WRITE (6,410) D1,D2,SZ(1)
      IF (UD-LD.GT.1.) GOTO 340
      IF (ABS(BD1-D1).LE.1.) GOTO 800
      BD1=D1
      GOTO 335
800   A(1)=A(2)=A(3)=A(4)=B(1)=B(2)=B(3)=B(4)=0.
```

```
      RETURN
      END
C*****************************************************************
C
C
C
*DECK RATE
      SUBROUTINE RATE
      DIMENSION IPOST(10)
      DIMENSION CAS(50), CNN(50)
      DIMENSION DTYPE(10)
      DIMENSION NN(50), A(50), B(50), SZ(50), PZ(50), CZ(50)
      DIMENSION AA3(10), AA4(10), TTLE(10), SS1(10), SS2(10), TT1(10), T
     1T2(10), AALS(10), AALP(10), AALC(10), RRATS(10), RRATP(10), RRATC(
     210), EET1(10), EET2(10), WW1(10), WW2(10)
      COMMON /BLOCK1/ NN,N,NVS,SZ,PZ,CZ,SE12,SE22,AT1,AT2,LU3,LU4,T1,T2,
     1A1,A2,SU3,SU4,SSQ1,SSQ2,PSQ1,PSQ2,CSQ1,CSQ2,PI,PI2,SU1,SU2,A,B,U1,
     2U2,SE1,SE2,SR1,SR2,PR1,PR2,CR1,CR2,REL,SQR2,NPOST,IPOST,ET1,ET2,W1
     3,W2,ES1,ES2,SC45,PC45,CC45,IFLAG,N3,CNN,TTT,CN3,U3,U4,WS1,WS2,CASL
     4EV,CAS,RELSUB,S1,S2,AJMX,BJMX,TM1,TM2,SE3,SE4,NUM,A3,A4,ASU1,BSU2,
     5D,FLD,FUD,GSE1,GSE2,IGOLD,INFN,LD,LL,UD,UL
      REAL MPI2,MPID,LL,LD
      WRITE (6,10)
C     *  PRINT HEADING FOR RCS HORIZONTAL
      WRITE (6,15)
15    FORMAT (/15H RCS HORIZONTAL)
      WRITE (6,30)
      D=A4/2.
      A(1)=A(2)=0.
      B(1)=-A4/4.
      B(2)=A4/4.
      CALL EVAL
```

```
      WRITE (6,110) D,SZ(1)
C     *  PRINT HEADING FOR BCS VERTICAL
      WRITE (6,10)
12    WRITE (6,14)
14    FORMAT (/12H BCS VERTICAL)
      WRITE (6,30)
      D=A3/2.
      A(1)=A3/4.
      A(2)=-A3/4.
      B(1)=B(2)=0.
      CALL EVAL
      WRITE (6,110) D,SZ(1)
C    *  PRINT HEADING FOR PATTERN NUMBER 1
      WRITE (6,10)
10    FORMAT (1H1)
      WRITE (6,20)
20    FORMAT (/17H PATTERN NUMBER 1)
      WRITE (6,30)
30    FORMAT (//4X,24H DISTANCE BETWEEN ROUNDS,6X,18H EXPECTED COVERAGE/
     1)
      FLD=0.
      FUD=0.
      INEW=1
40    GOTO(50,70,80,90) INEW
50    DO 60 I=1,2
60    A(I)=0.
      LD=0.
      LL=0.
      UL=A4*2.
      IGOLD=1
      CALL GOLD
      GOTO 100
```

```
70      FLD=FUD
        FUD=SZ(1)
        CALL GOLD
        GOTO 100
80      FLD=SZ(1)
        CALL GOLD
        GOTO 100
90      FUD=FLD
        FLD=SZ(1)
        CALL GOLD
        GOTO 100
100     B(1)=-.5*D
        B(2)=D*.5
        CALL FVAL
        WRITE (6,110) D,SZ(1)
110     FORMAT (8X,F6.1,7H METERS,13X,F7.5)
        IF (UD-LD.GT.1.) GOTO 40
C     *  PRINT HEADING FOR PATTERN NUMBER 2
105     WRITE (6,10)
        WRITE (6,120)
120     FORMAT (/17H PATTERN NUMBER 2)
        WRITE (6,20)
        FLD=0.
        FUD=0.
        INEW=1
140     GOTO(150,170,180,190) INEW
150     DO 160 I=1,2
160     B(I)=0.
        LD=0.
        LL=0.
        UL=A3*2.
        IGOLD=1
```

```
      CALL GOLD
      GOTO 200
170   FLD=FUD
      FUD=SZ(1)
      CALL GOLD
      GOTO 200
180   FLD=SZ(1)
      CALL GOLD
      GOTO 200
190   FUD=FLD
      FLD=SZ(1)
      CALL GOLD
      GOTO 200
200   A(1)=D*(-.5)
      A(2)=D*.5
      CALL EVAL
      WRITE (6,110) D,SZ(1)
      IF (DD-L).GT.1.) GOTO 1-0
      DO 210 I=1,2
      A(I)=0.
210   B(I)=0.
      RETURN
      END
```

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